Change through biodiesel production in Norte de Minas, Brazil? An assessment of a complex rural system

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ZUSAMMENFASSUNG

Ländliche Gebiete in Brasilien sind mit vielfältigen Problemen konfrontiert. Gleichzeitig bekommt das Thema Biokraftstoffe immer mehr Relevanz. Um gleichzeitig eine nachhaltige, bezahlbare Biodieselproduktion zu fördern und die sozialen Probleme auf dem Land anzugehen, wurde 2004 das brasilianische Biodieselprogramm PNPB beschlossen.

Diese Arbeit untersucht, welche Veränderungen die Produktion von Ölpflanzen im Rahmen des Biodieselprogramms für Kleinbauern mit sich bringt und ob dies zu mehr Resilienz der kleinbäuerlichen Landwirtschaft im Norden des Bundesstaates Minas Gerais, einer strukturschwachen und von Armut und Trockenheit geprägten Region, beiträgt.

Untersucht wurden landwirtschaftliche Systeme in zwei Regionen, die sich in ihrer Struktur und Markteinbindung grundlegend unterscheiden. Als Ergebnis lässt sich feststellen, dass das Biodieselprogramm je nach Region sehr unterschiedliche Auswirkungen hat.

In der bereits marktwirtschaftlich orientierten Region mit einer gut funktionierenden Kooperative, die die Bauern bei der Vermarktung und durch Agrarberatung unterstützt, bringt der Anbau von Soja für Biodiesel einen geringen Mehrverdienst und wenig Umsetzungsprobleme. Das Agrarsystem selbst wird jedoch weder resilienter noch werden die Bauern abhängig vom Biodieselprogramm, da es weitere gut etablierte Absatzwege gibt.

Anders stellt sich die Situation in den strukturschwachen Regionen dar, wo Kleinbauern Rizinus als neue Fruchtart in ihre Produktion aufgenommen haben. Diese Bauern waren die eigentliche Zielgruppe des Biodieselprogramms. Tatsächlich profitieren sie aber weit weniger davon. Zwar konnten die Rizinusbauern durch das PNPB kurzfristig einen Einkommenszuwachs erzielen, aufgrund verschiedener Widrigkeiten war dieser jedoch nicht von Dauer und die meisten Kleinbauern stellten die Produktion von Ölfrüchten wieder ein. Insgesamt ist die Struktur des Agrarsystems der Rizinusbauern sehr fragil. Das bedeutet, dass sich externe Störungen selbst verstärken und das System aus dem Gleichgewicht bringen können. Dies und die genannten Schwierigkeiten führen zu einer Schwächung der Resilienz des Gesamtsystems durch das PNPB. Der Kern des Agrarsystems mit seiner ursprünglichen Produktion von Rindfleisch und Produkten zur Selbstversorgung, deren Überschuss verkauft wird, kann jedoch als resilient eingestuft werden.

Alternativ zur Teilnahme am Biodieselprogramm könnte eine auf mehr Diversität ausgelegte, mit Methoden der Agrarökologie und traditionellem Wissen arbeitende, regional vernetzte Produktionsweise, die die Autonomie der Kleinbauern und ihre Macht gegenüber ihren Abnehmern durch den Zusammenschluss in Kooperativen stärkt, zu mehr Resilienz führen.

ABSTRACT

Rural areas in Brazil face various problems. At the same time, biofuels are becoming more and more relevant. In order to simultaneously promote sustainable, affordable biodiesel production and to address the social problems in the countryside, the Brazilian biodiesel program PNPB was approved in 2004.

This thesis examines the changes induced by the production of oil crops under the biodiesel program for family farmers, and whether this contributes to the resilience of family farming in the north of the state of Minas Gerais, a structurally weak region characterized by poverty and drought.

Agricultural systems were studied in two regions, which differed fundamentally in their structure and market integration. As a result it can be stated that the biodiesel program has very different effects depending on the region. In the already market-oriented region with a well-functioning cooperative, which supports the farmers in marketing and agricultural advice, the cultivation of soybeans for biodiesel provides a small additional income and little implementation problems. However, neither the agricultural system itself becomes more resilient nor do the farmers depend on the biodiesel program as there are other well-established distribution channels.

The situation is different in the structurally weak regions in which small farmers have included castor as a new crop in their production. These farmers were the actual target group of the biodiesel program. In fact, they benefit far less. Although the castor bean farmers were able to increase their income in the short term by the PNPB, this was not permanent due to various adversities. Thus, they stopped the production of oil crops. Overall, the structure of the agricultural system is very fragile. This means that external disturbances can intensify themselves and can bring the system out of balance. This and the difficulties mentioned led to a weakening of the resilience of the overall system by the PNPB. However, the core agricultural system, with its production of beef and products for self-sufficiency and the surplus being sold to the market can be classified as resilient.

As an alternative to the participation in the biodiesel program, a more diversified farming approach, such as using methods of agricultural ecology and traditional knowledge and the establishment of cooperatives to strengthen the autonomy of small-scale farmers and their power towards contract partners, could lead to more resilience.

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PREFACE

Why did I dare the adventure to explore rural development and social progress in Brazil? Because I wanted to do something meaningful and a Brazilian song from my favourite singer-songwriter *Die Kleingeldprinzessin* (The pocket money princess) convinced me to do this in Brazil. She often sings about the social and ecological effects of our globalised world – sometimes in Portuguese, sometimes in German – one song contains the line “das Gegenteil von gut ist leider oft gut gemeint” (the opposite of ‘good’ often is ‘well-intended’). She lent this expression from Kurt Tucholsky and sadly it corresponds with the findings in this research study.

Nevertheless, I met wonderful people in the countryside of Brazil who keep seeing the bright side of life and have a strong optimism. Their optimism is the basis for a development towards a better future.

Above all Estela da Costa Parreira who runs a farm in Matias Cardoso amazed me with her energy and power. I dedicate this thesis to her.

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LIST OF ABBREVIATIONS

Abiove	Associação Brasileira das Indústrias de Óleos Vegetais (Brazilian Association of Vegetable Oil Industries)
ANP	Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (National Agency for Petroleum, Natural Gas and Biofuels)
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
CG	Chapada Gaúcha (municipality in northern Minas Gerais)
COOAPI	Cooperativa Agropecuária Pioneira (Agricultural cooperative in Chapada Gaúcha)
COOPERSAM	Cooperativa dos Agricultores Familiares de Santa Maria (Cooperative of family farmers in Santa Maria)
CPT	Commissão Pastoral da Terra (Pastoral Commission of Land)
DAP	Declaração de Aptidão ao Pronaf (Declaration of aptitude for Pronaf)
DRBP	Darcy Ribeiro Biodiesel Plant
EMATER	Empresa de Assistência Técnica e Extensão Rural (Technical Assistance and Rural Extension Company)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Agency)
EPAMIG	Empresa de Pesquisa Agropecuária de Minas Gerais (Agricultural Research Insitute of Minas Gerais)
GESTA	Grupo de Estudos em Temáticas Ambientais (Study Group on Environmental Issues) situated at the UFMG (Federal University of Minas Gerais)
FAO	Food and Agricultural Organisation of the United Nations
FONA	Forschung für Nachhaltigkeit (Research for Sustainability)
IEA	International Energy Agency
IBGE	Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics)
INCRA	Instituto Nacional de Colonização e Reforma Agrária (National Institute of Colonization and Agrarian Reform)
MAPA	Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Supply)
MC	Matias Cardoso (municipality in northern Minas Gerais)

MDA	Ministério do Desenvolvimento Agrário (Ministry of Agrarian Development)
MST	Movimento dos Trabalhadores Rurais Sem Terra (Movement of the Landless Rural Workers)
PAA	Programa de Aquisição de Alimentos (Food Acquisition Program)
PES	Payments for Environmental Services
Petrobras	Petróleo Brasileiro S.A. with the subsidiary Petrobras Biocombustível (Pbio)
Petrovasf	Petroleo Verde do Vale do São Francisco Ltda.
PNPB	Programa Nacional de Produção e Uso de Biodiesel (National Program for Production and Use of Biodiesel)
PNAE	Programa Nacional de Alimentação Escolar (National School Meals Program)
ProÁlcool	Programa Nacional do Álcool (National Ethanol Program)
PROAMBIENTE	Programa de Desenvolvimento Socioambiental da Produção Familiar Rural (Program for the Social/Environmental Development of Rural Family Production)
Pronaf	Programa Nacional de Fortalecimento da Agricultura Familiar (National Program for the Strengthening of Family Farming)
R$	Real/Reais (Brazilian currency unit Real)
STR	Sindicato dos Trabalhadores Rurais (Rural Workers' Union)
Ubrabio	União Brasileira do Biodiesel e Bioquerosene (Brazilian Union for Biodiesel and Biokerosene)
UFMG	Universidade Federal de Minas Gerais (Federal University of Minas Gerais)
WBGU	Wissenschaftlicher Beirat für Globale Umweltveränderungen

1 INTRODUCTION

Concerning energy supply, it is becoming more and more evident that the world is facing several serious challenges in the future. A rising demand for energy (IEA, 2013) and the simultaneous depletion of fossil oil sources (IEA, 2011) which let the oil price increase continuously requires the investigation of alternative energy sources. The discussion about the reduction of greenhouse gases to mitigate climate change constitutes another reason why scientists as well as politicians search for new options. Biofuels, which can be produced from renewable raw material in many different parts of the world, have been suggested as one possible solution. Politicians, researchers, farmers, and industry share the objective of killing two birds with one stone: to find a solution for the reduction of greenhouse gases from the transport sector and to adapt to rising oil prices. Increasingly more countries have begun to politically support the production and use, as well as research and development of alternative energies like wind and solar power and biofuels. But it is not only energy security and the mitigation target to climate change that push bioenergy on the political agenda. There is also the hope that by supporting (for example) biofuel production another goal can be achieved: the generation of new sources of income, jobs, and energy for family farmers and farm workers in rural areas who have often been excluded from economic progress (Rossi & Lambrou, 2009; WBGU, 2009).

However, the sustainability of biofuel production is questioned in the scientific debate as well as in the public political discourse. Continuously high average food prices (FAO, 2014), new research results concerning the greenhouse gas reduction potential of biofuels, and the indirect land use changes caused by biofuels are reasons for concern (German National Academy of Sciences Leopoldina, 2012). As there is limited agricultural land it comes to a competitive situation between production of food and energy crops (Klohn & Voth, 2010). This development might lead to a redefinition of rural areas not being only a supplier of food, but of energy as well.

1.1 Rural development and social progress

Rural development is defined by the Food and Agricultural Organisation of the United Nations (FAO) as a process which has economic and social objectives with the goal of changing rural society to improve the livelihood for rural people (Oakley & Garforth, 1985). Anríquez and Stamoulis (2007) add that the improvement of the population's standards of living or welfare has to be sustained. Often rural development is closely linked with agricultural development as agriculture is often the main source of income in rural areas. But rural development is more

than economic growth. According to Anríquez and Stamoulis (2007, p. 3), “the provision of social services to the rural poor” and “human capital development” are main aspects of rural development.

This definition is very close to the definition of social progress used by the Social Progress Imperative which yearly measures the Social Progress Index: “We define ‘social progress’ as the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential.“ (Stern, Wares, & Hellman, 2016, p. 4)

In Brazil, rural development was undergoing different stages of focus according to the political and societal situation. Prominent topics were: rural poverty and inequality reduction, agrarian reform, hunger prevention, and later the special needs of peasants, environmental sustainability issues, and social rights of underprivileged people.

From 1970-1990, rural development was almost exclusively ruled by the state and compensatory measures were the main instrument to support farmers who struggled to modernize their agriculture to fit into the capitalistic model (Schneider, Shiki, Belik, & Van der Ploeg, 2010). In the late 1980s, after the military dictatorship was overcome and the country returned to democracy, social movements and civil society organisations changed their role from merely protesting to proactively participating in rural policy (Schneider et al., 2010).

Pushed by their agenda, especially due to the actions of the Brazilian Landless Movement (MST) and the Land Pastoral Commission (CPT), during the 1990s the focus of rural development was on land reform (Veltmeyer & Petras, 2002; Wolford, 2003). This was a great success because it had been debated since the 1950s. Out of this context of social conflicts the Ministry of Agrarian Development (MDA) emerged as counterpart to the existing Ministry of Agriculture, Livestock and Supply (MAPA). The MDA’s focus is more towards family farming and agrarian reform than to economic growth of agri-business which is promoted by MAPA. Also in this period during the 1990s, the National Program for Family Farming Enhancement (PRONAF) was founded. It was the first agricultural policy which recognised the significant scale differences and requirements between family farmers and large-scale industrial farmers (Schneider et al., 2010). The provision of production support and credits with special conditions for family farmers are two of the main concerns of PRONAF, although it has shortcomings concerning marketing options (S. Costa, Kohlhepp, Nitschack, & Sangmeister, 2010), and its effect on the reduction of regional or social inequalities is questioned (Mattei, 2015). Another important achievement of the 1990s era is the implementation of a retirement scheme which is according to Delgado and Theodoro (2005) one of the most effective public policies with significant economic and social redistributive effects in rural areas.

From 2000 onwards, the Brazilian State has increased its attempts to fight hunger and poverty in rural areas via conditional cash transfers. *Bolsa Escola* (school grant), which later merged into *Bolsa Família* (family scholarship), and *Fome Zero* (zero hunger) are three of the main instruments of social policy. Until today they contribute significantly to rural peoples' welfare although it is argued if this contribution is sustainable (A. Hall, 2006). Another important initiative was the Food Acquisition Program (PAA) launched in 2004. Through this program, family farmers and public institutions like schools and hospitals were linked to each other to build local market relationships and guarantee a food supply for people in food insecurity.

In 2006 the term *family farmer* (in Portuguese *agricultor familiar*) was defined by law (law Nº 11.326; Presidência da República, 2006) to specify the requirements under which family farmers can get access to different governmental programs and fair loans. The law states that family farmers must not own land larger than a certain area (four *módulos fiscais*[1]), they must primarily obtain manual labour from their own family, their income must predominantly originate from economic activities linked to their own establishment, and the head of the establishment has to be a family member. Those who comply with these rules can obtain a document known as a DAP (*Declaração de Aptidão ao Pronaf*).

The DAP can also be awarded to cooperatives if a certain percentage of their members hold the DAP individually.

During the recent past the environment and agroecology came more into focus of rural development policies. PROAMBIENTE (Program for the Social/Environmental Development of Rural Family Production) is a socio-environmental development program which established Payments for Environmental Services (PES) to family farmers in the Amazon region. However, according to Hall (2008), it has some shortcomings. Besides the more environmentally friendly orientation of rural policies, another approach is set into praxis: making long-standing institutional markets accessible to family farmers (Schneider et al., 2010). Combining these two aspects, the National Program for Production and Use of Biodiesel (PNPB) was established in 2004. It aims to become less dependent on fossil diesel by producing biodiesel from different raw materials and at the same time provide new income options for family farmers through an integration into the production chain.

The current political understanding recognises the importance of family farming for the conservation of nature as well as in terms of local and regional food supply. Through incentives

[1] According to the National Institute of Colonization and Agrarian Reform (INCRA), the *módulo fiscal* is a unit of measure expressed in hectares, fixed for each municipality. The size varies according to the peculiarities of each region: predominant type of exploitation, the average income obtained by it (which is directly associated to the type of soil, climate, relief, etc.), other existing holdings in the municipality, which are important according to income or area used, and the concept of family ownership (INCRA, 2008).

those functions shall be integrated into the capitalist economy, and simultaneously farmers shall become less dependent on state programs. While in the past the state was the main actor in creating and shaping policies lately social movements and organisations and local actors are more and more involved.

Despite these well-intended policies the reality shows that the inequality of land ownership between family farmers and agribusinesses has grown over the past decades and a further concentration of land has happened (Mattei, 2015).

Table 1 gives an overview over the recent rural development programs in Brazil.

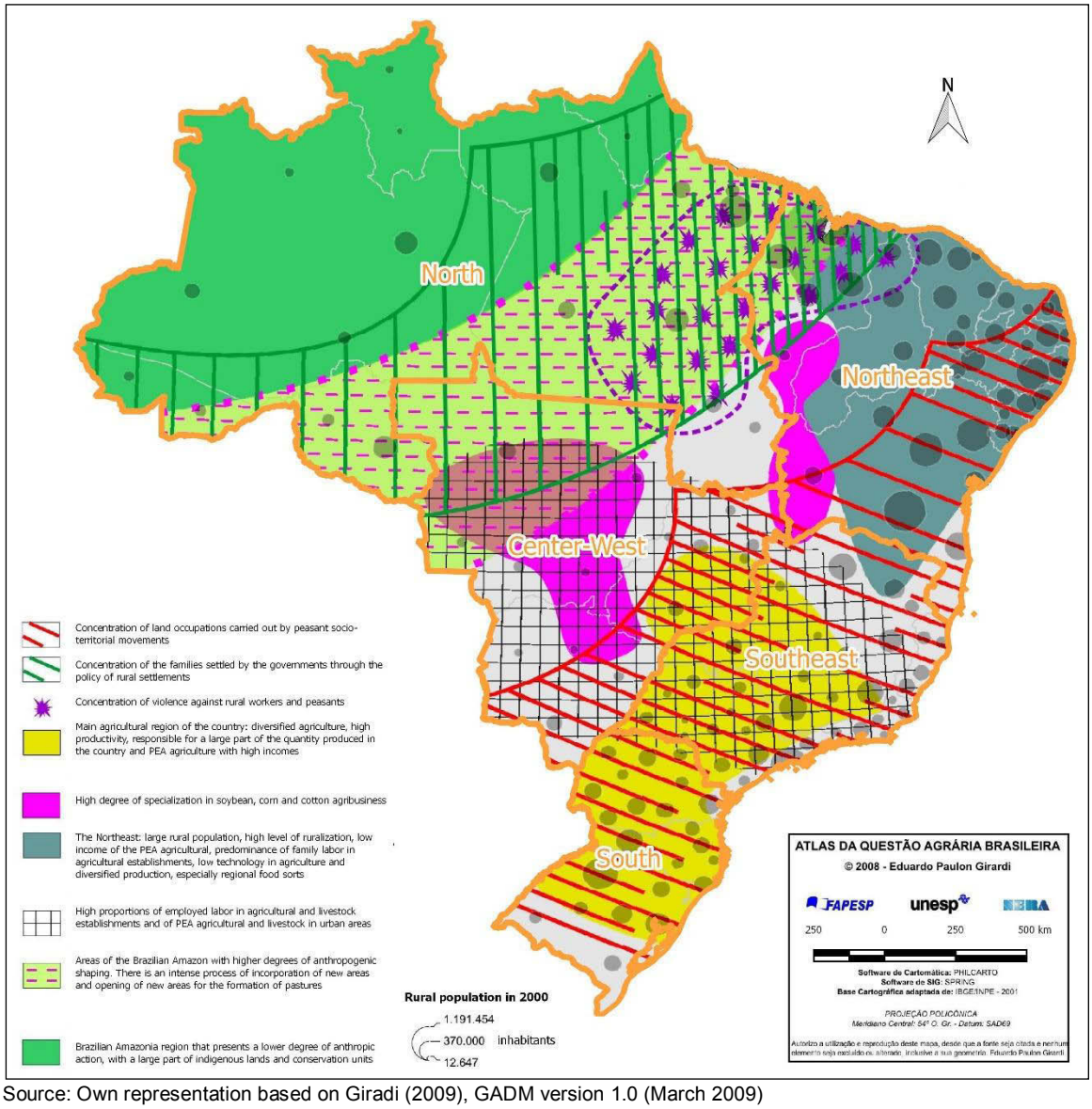
Table 1: Overview of rural development programs in Brazil

Program	**Year**	**Objective**
National Program for Family Farming Enhancement (PRONAF)	1996	Provision of credits with special conditions and production support for family farmers
Código Florestal (Forestry Code)	1934, updated 2012	Maintaining biodiversity through legal reserves on 20% to 80% of rural properties' area depending on the biotope
Bolsa Escola (School Grant)	2001	Financial transfer to poor families who ensure that their children attend school
Bolsa Família (Family Scholarship)	2003	Financial transfer to poor families who ensure that their children attend school and are vaccinated
Fome Zero (Zero Hunger Program)	2003	Ensure food security for all through an integration of health, nutrition, social assistance, education, and agriculture
Food Acquisition Program (PAA)	2004	Guarantee healthy food supply for people in food insecurity through strengthening local networks and regional supply chains between public organisations and family farmers
Pro-Environment-Program (PROAMBIENTE)	2004	Payment for environmental services in the Amazon region

Program	Year	Objective
National Program for Production and Use of Biodiesel (PNPB)	2004	Production of Biodiesel from different raw materials to become less dependent on fossil fuel, including family farmers into the production chain

1.2 Brazilian agriculture

Current dynamics in Brazilian agriculture are still strongly influenced by historical processes which let to very diverse patterns in different parts of the country (see Figure 1).



Source: Own representation based on Giradi (2009), GADM version 1.0 (March 2009)

Figure 1: Brazilian agriculture

In the southern part, descendants of European settlers live as family farmers and run their agricultural businesses intensely. In the southeast large agribusinesses grow coffee and sugarcane in huge monocultures and employ a high percentage of seasonal workers. In contrast to that, the northeast of Brazil is characterised by small and poor family and subsistence farmers who often live close to or under the poverty line. The northern region is covered by the Amazon rainforest which is partly protected area and refugium for indigenous people but gets more and more fragmented due to governmental settlement programs for landless people and agribusinesses expanding into this area. In the center-west soy bean-, corn-, and cotton-producing large agribusinesses determine the landscape and are still expanding into the wet savannahs (*campos cerrados*) and into the Amazon forest. This situation shows that the historical slope of development still exists between north and south (Kohlhepp, 2010). According to Mattei (2015), the agricultural modernisation process from 1960 to 1980 supported by state interventions even aggravated the marginalisation process.

Not only historical influences have formed the current picture, but also recent rural policies. Although President Lula da Silva (Lula) initiated several policies to support family farming, he also supported the modernisation process under the green revolution paradigm and benefited agro-industrial farmers by fiscal incentives and exemptions to increase their competitiveness on the world market (Mattei, 2015). During the years from 2003 to 2011, the Brazilian GDP grew consistently and Brazil developed into one of the largest exporters of the world. Due to a lack of competitiveness of industrialized products in international markets, the main exported goods were agricultural products and mineral extraction commodities (Mattei, 2015). This process of agricultural modernisation did not only cause a lot of environmental problems (monocultures, water contamination, soil degradation, deforestation) but also fostered the slowdown of agrarian reform (Neuburger, 2010). The reason is that land not intensively used before became more valuable, which in turn caused land speculations (Tapiador, 2010) and strong lobbying groups of large-scale farmers protecting their claims (Burger, 1994). The result was an even higher land concentration. This is also displayed by the Gini index of land distribution, which has grown during the last decades despite being one of the highest worldwide even before. After a stagnation from 1985 (0.857) to 1995 (0.856) it rose to 0.872 in 2006 (IBGE, 2006). The unequal land distribution is also shown by the last census: despite representing just 15.6 % of all farms, non-family farms occupy 75.7 % of the area (see Table 2). Nevertheless family farm agriculture is an important pillar of food production in Brazil. It provides around 75 % of total rural employment and supplies 70 % of the country's domestic food consumption (CAISAN, 2011; Schneider et al., 2010; Sparovek et al., 2007): 87 % of manioc, 70 % of beans, 46 % of corn, 34 % of rice, 59 % of pork production, 50 % of poultry, and 58 % of all dairy products originate from family farming (MDA, 2009a).

Table 2: Family and industrial agriculture profile in Brazil

	Family farmers	Non-family farmers	Total
Number of agricultural businesses (units)	4 367 902	807 587	5 175 489
Number of agricultural businesses (percent)	84.4 %	15.6 %	100 %
Area of agricultural businesses (hectare)	80 250 453	249 690 940	329 941 393
Area of agricultural businesses (percent)	24.3 %	75.7 %	100 %
Gross production value (R$)	54 billion	89 billion	143 billion
Gross production value (%)	38 %	62 %	100 %
Productivity R$/ha/year	515	322	

Source: IBGE - Censo Agropecuário 2006 (MDA, 2009a)

Table 2 shows the number of agricultural businesses and the distribution of land among family farmers and non-family farmers. It is notable that 84.4 % of all agricultural businesses are family farms but just 24.3 % of the agricultural land is used by them. Despite this fact they exceed the non-family farmers in the share of gross production value (38 %) proportionately to the farmed area and their productivity per hectare and year (515 R$/ha/year) is more than one and a half times the productivity of non-family farmers (322 R$/ha/year).

In contrast to non-family farmers who often specialise in one crop which they grow in monocultures, family famers production mostly orientates on the needs of the family, available resources (land, workers) and knowledge which mostly constitutes in a much more diversified product range. Their first aim is not to maximise profit but to cover the basic needs of the family members. The resulting self-consumption agriculture is assisted by a production for local markets or wage labour to cover other needs. Family farmers follow their traditional knowledge and production logic combining crop production with animal husbandry. This diversification of production minimises their vulnerability (SICK, 1993). Using mostly family labour, they farm their units more intensely than agro-industrial farms while at the same time using less external inputs (fertilizer, pesticides, etc.). Being dependent on keeping their land fertile and not having huge machinery at their disposal, they mostly work more environmentally friendly than agro-industrial farms. Economic decisions are based on the availability of production resources (land, labour), traditional knowledge, and spatial conditions.

The processes of modernisation and globalisation alter the circumstances in which family farmers are producing. According to Sick (1993), the transition from subsistence agriculture to

market oriented agriculture has two sides: on the one hand it has the potential for higher profit, but on the other hand it bears the risk of becoming dependent on trade, transportation, and marketing.

As the group of family farmers is not homogeneous, different classifications have been invented. Lamarche (1998) distinguishes four types of farmers according to their grade of orientation towards the market and their grade of division of family and business: A – business (*empresa*), B – family business (*empresa familiar*), C – peasant or subsistence agriculture (*agricultura camponesa ou de subsistência*), and D – modern family farming (*agricultura familiar moderna*). The first two types (A and B) orientate themselves very much towards the market and develop a dependence on it. C and D are more market independent. While in type A and D a separation between family and business takes part, in the other two types (B and C) the family is very much integrated into the business. According to Lamarche (1994), typical peasants who are weakly integrated into the market, forming a rural community and farming land which is not only a production asset but also a cultural heritage, represent only 22 % of all farmers in Brazil. However, the author also concludes that the other three types of family famers do not differ radically from the peasant type.

Besides single farmer types there also exist different types of farmers' groups living and/or working more or less closely together. One form is the *cooperative* which is a modern form of common farming, where members voluntary farm on land they own themselves or which is owned by the cooperative or the state, and use machinery commonly (Burger, 1994). Reasons to choose a cooperative production are to escape from exploitation by landlords and to become more efficient, which is why this way of farming is seen as an alternative to the large-scale capitalist farm (Burger, 1994). European immigrants who were familiar with cooperatives brought the cooperative concept to Brazil and fuelled its development during the twentieth century (Battilani & Schröter, 2012). Some cooperatives just share resources and equipment, while others also have a collaborative commercialisation.

Another more loose union of farmers are *farmers associations*. They share know-how, sometimes equipment and may support each other through neighbourly help or collective marketing. These associations can have different legal status.

An even looser conglomerate of farmers are the *assentamentos* (settlements) which are part of the agrarian reform. Through public support landless farmers are provided with small lots of land to settle down. On the one hand this may be seen as success of MST and other organisations who fight for the rights of landless people. On the other hand, these new settlements are often located in areas with unfavourable economic and ecologic conditions which causes new impoverishment and migration processes (Neuburger, 2010). As farmers from different regions and origins are colonized in these settlements they do not necessarily

have more in common than the will to own a piece of land. This makes it difficult to establish any collaborative working as it originally was the aim of the MST.

Rural exodus to cities especially of young people is one of the major rural problems (Tapiador, 2010). During recent years the rural population decreased for the first time not only relatively to the total population but also in absolute numbers (Neuburger, 2010). This process is accelerated by the globalisation process because family farmers are on the globalised market economically not competitive with large-scale agribusinesses, and seasonal labourers are less needed due to the use of modern machinery.

1.3 Biofuels in Brazil

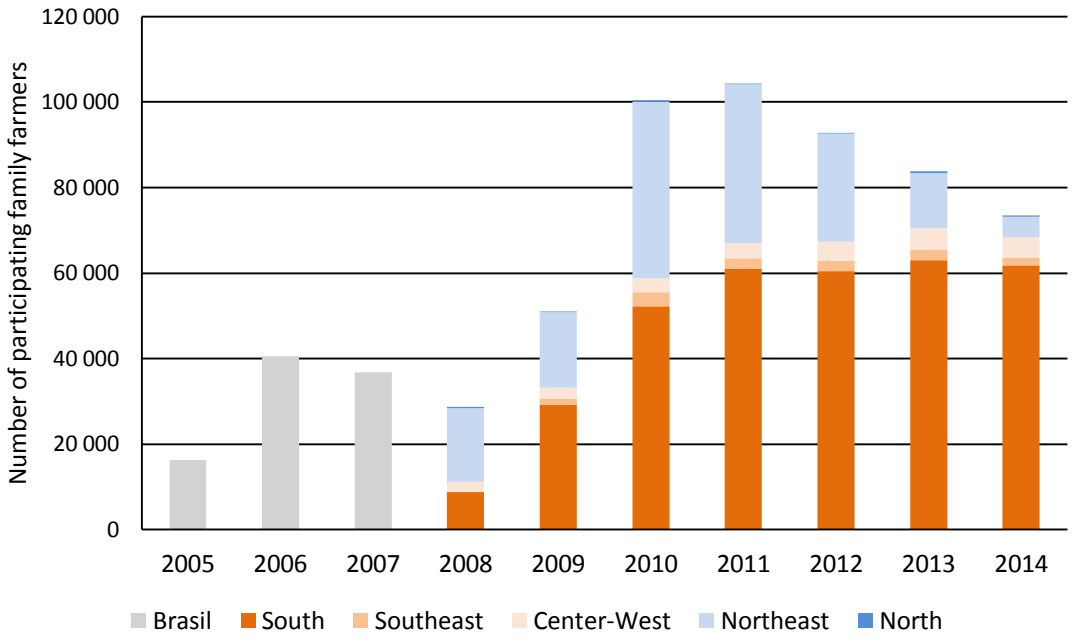
The Brazilian biofuel production has a long tradition. Ethanol production from sugar cane is well known and has been strongly encouraged since the 1970s through the PROALCOOL program (Goldemberg, Coelho, Nastari, & Lucon, 2004). This program strengthened large-scale farmers in the southeast and central regions of Brazil, whereas small-scale farmers were not competitive enough to benefit from the program, even though they were initially included (J. Hall, Matos, Severino, & Beltrão, 2009). In the northeast region large-scale producers could even enlarge their land properties while small-scale farmers lost their land (Lehtonen, 2011).

Since 1980, the production of biodiesel has been politically supported through the PRO-ÓLEO program which was abandoned after a drop of international petroleum prices in 1986 (Pousa, Santos, & Suarez, 2007). It was followed by the PROBIODIESEL program in 2002 and the National Program for the Production and Use of Biodiesel (PNPB) in 2004 (César & Batalha, 2010a). These programs aimed to develop a technology and production chain to substitute fossil diesel proportionately. In the most recent program, the PNPB, social inclusion through the integration of family farmers into the biodiesel value chain has been enforced for the first time (MME, 2012). Family farmers are incentivized to incorporate the production of oil crops into their agricultural systems. The target group are family farmers, especially in the northeast of Brazil (Abramovay & Magalhães, 2008), who can be categorised as underprivileged, mostly poor and vulnerable (Lemos, 2007). These farmers need a future perspective to avoid rural exodus to the cities. They need a possibility to make their farming system more resilient against economic and climatic disturbances so that they can make a sustainable living. The aim of the PNBP was to create an extra income source and new jobs, especially in disadvantaged rural areas, to provide this perspective (SAF & MDA, 2010). Moreover, biodiesel was intended to be produced from different raw materials, with competitive prices and of good quality (SAF & MDA, 2010).

The PNPB also provided a timetable for the intended blending quota which rose from 2% (B2) in 2008 to 5% (B5) in 2010 and 7% (B7) in 2014. Besides the blending quota, several measures were established. Firstly, there was the *Social Fuel Seal* (*selo combustível social*). This measure established minimum percentages of raw material that had to be purchased from family farmers, and provided technical assistance, contracts and minimum prices. Secondly, tax breaks, low-interest loans for industry, and auctions conducted by the National Agency for Petroleum, Natural Gas and Biofuels (ANP), where Petrobras (the parastatal oil company) guarantees the purchase of biodiesel, were introduced. In these auctions 80 % of the biodiesel demand has to be bought from biodiesel plants which own the *Social Fuel Seal*. This provides a strong incentive for biodiesel companies to obtain the seal.

The *Social Fuel Seal* guarantees the support of social and economic development in less developed regions (César & Batalha, 2010a). It is awarded to biodiesel plants which fulfil certain criteria: closing of contracts with family farmers (who obtained the DAP) under a certain procedure, acquiring a minimum percentage of raw material from family farmers, and supporting family farmers through technical assistance by agricultural advisors (SAF & MDA, 2010). These advisors shall promote the production of food crops and contribute to family's food self-sufficiency (MDA, 2009b).

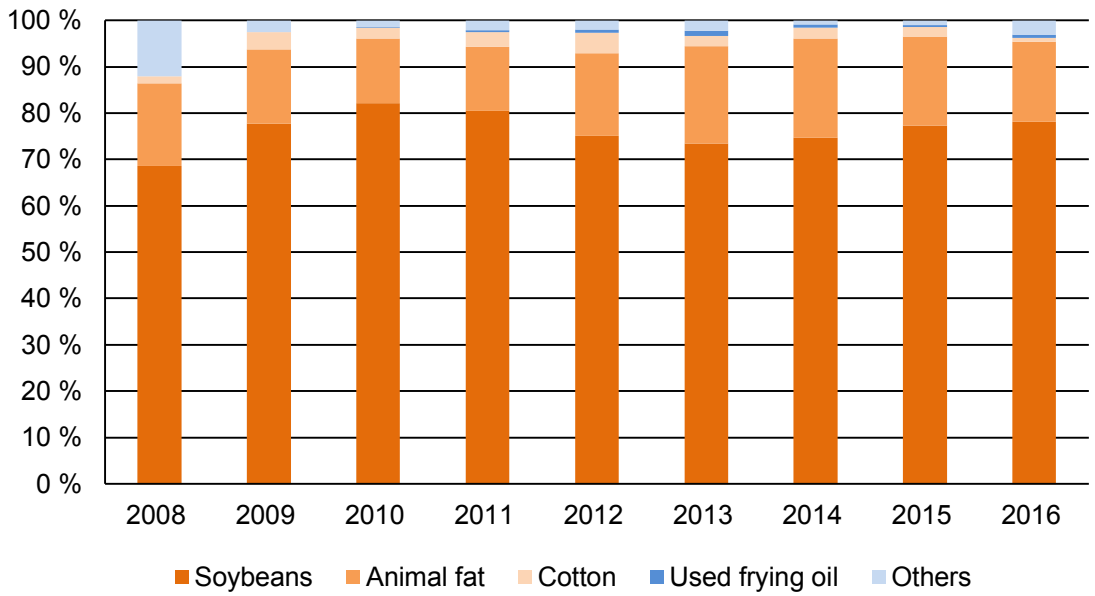
The evolution of the PNPB was ambivalent. As the biodiesel sector grew faster than expected, the blending quota was raised earlier than planned by the directive. Due to pressure from the biodiesel industry the quota was raised to 3% in July 2008, to 4% in July 2009 (Wilkinson & Herrera, 2010) and in January 2010 the directive was adjusted to a 5% mandatory blending quota (CNPE, 2009). Until 2016 the mandatory blending quota was increased step-by-step to 8% and will rise up to 10% in 2018 (Presidência da República, 2016). On the other hand, the number of family farmers included lags behind the target of 200 000 participating family farmers and the regional distribution of participating family farmers has a focal point in the south of Brazil, which is not the region where the poorest farmers live (see Figure 2).



Source: MDA, SAF & INCRA (2016); SAF & MDA (2015)

Figure 2: Number of family farmers participating in the PNPB

Possibly also in response to political pressure from the biodiesel industry, the minimum percentage of total expenditures for feedstock from family famers as a requirement to obtain the *Social Fuel Seal* was decreased in 2009 (César & Batalha, 2010a). Furthermore, the calculation method was modified. Before, it had to be a minimum percentage of raw material, now it can be a minimum percentage of total expenditures which have to be invested into family farmers (input, technical assistance, transportation, packaging material, etc.) to get the seal (MDA, 2009b). Depending on the region in Brazil these percentages currently lie between 15 and 40 % (MDA, 2015). Moreover, the diversification in processed raw material did not change much although this was one of the goals of the program. In 2016 the following raw materials contributed to the biodiesel production in Brazil: 78 % soybeans, 17 % animal fat, 1 % cotton, 1 % used frying oil and 3 % other raw material (ANP, 2013). This mix was more or less stable during the last years (see Figure 3).

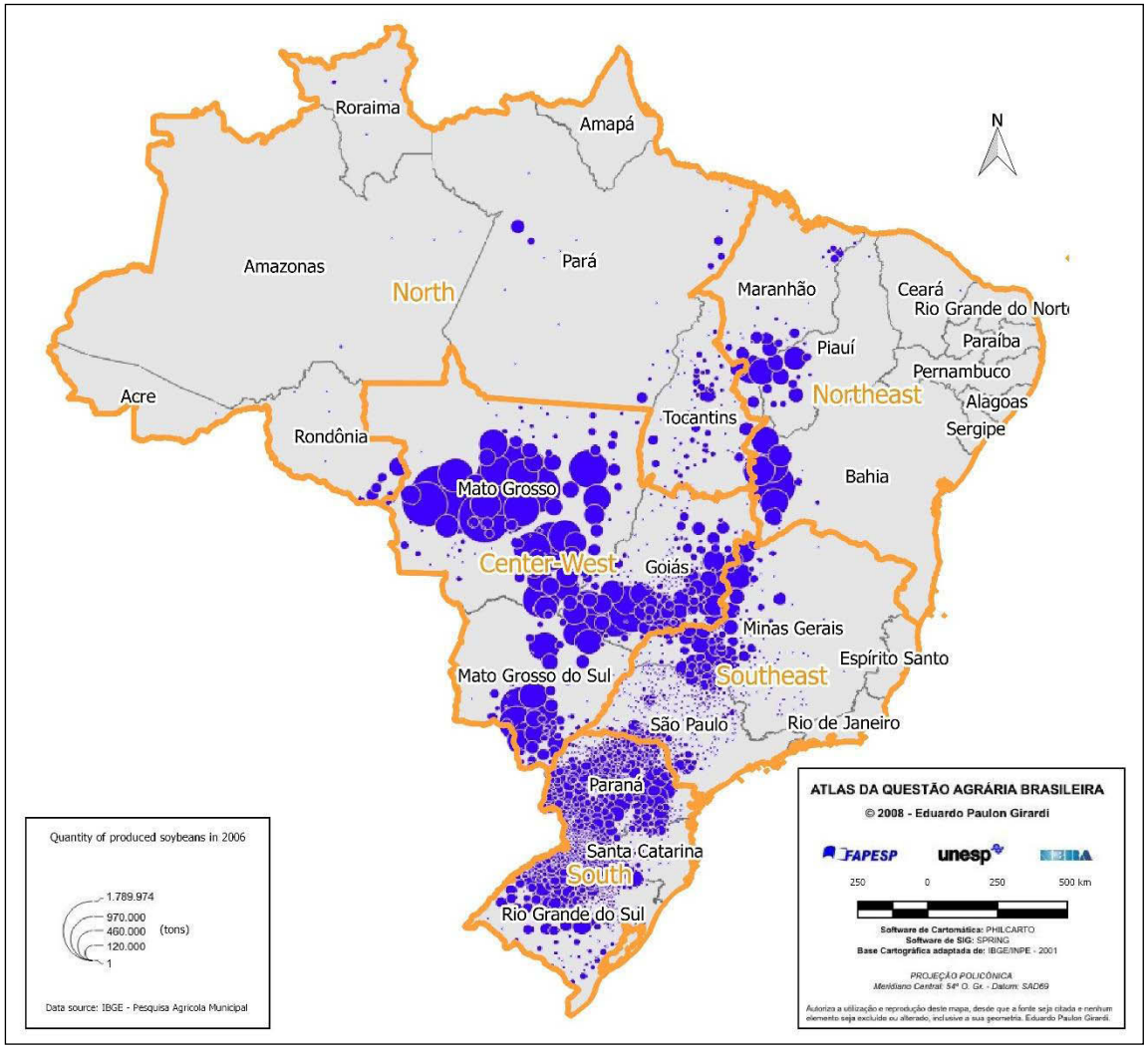


Source: ABIOVE (2016)

Figure 3: Mix of raw material used for the production of biodiesel from 2008 to 2016

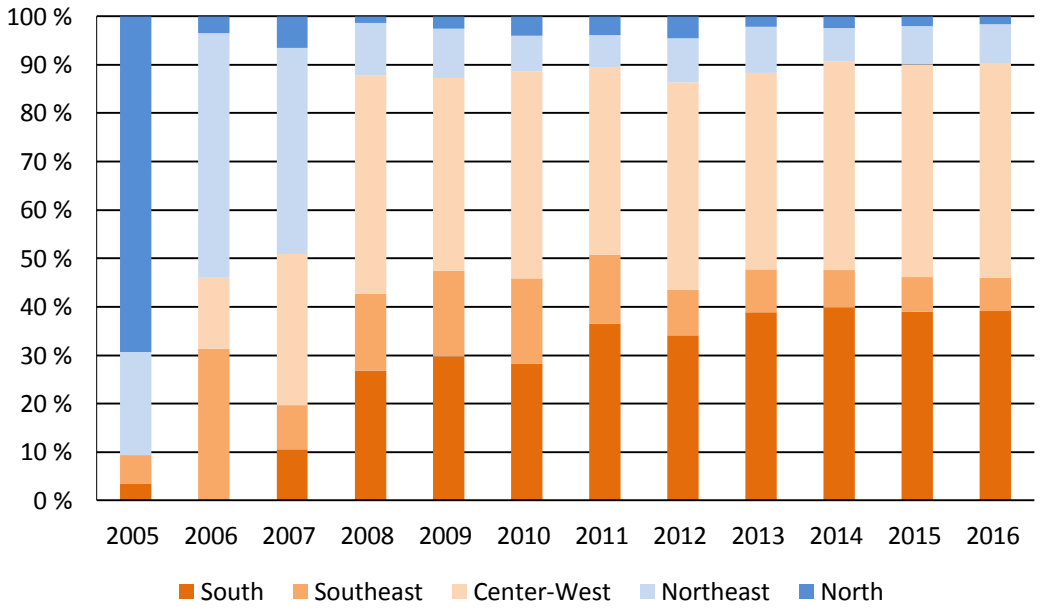
According to Franco et al. (2010), family farmers have a minor role in biodiesel production because biodiesel companies prefer soybean (*Glycine max)*, which is the most important raw material for biodiesel production at the moment and is mainly produced by large-scale farms in the center-west or cooperatives in the south of Brazil (Kovac & Zimmer, 2012) (see Figure 4). The regional distribution of biodiesel production also shows a focal point in the south and center-west regions (see Figure 5).

However, some authors argue that soybeans are not a suitable feedstock for biodiesel production both in socio-economic and environmental terms (Faria, 2009; Garcez & Vianna, 2009; Kovac & Zimmer, 2012).



Source: Own representation based on Giradi (2008), GADM version 1.0 (March 2009)

Figure 4: Distribution of soybean production in Brazil 2006



Source: Own representation based on ABIOVE (2016)

Figure 5: Regional distribution of biodiesel production in Brazil 2005-2016

But then, castor bean (*Ricinus communis*) has been strongly promoted as the crop which fits best with the family farming system because “it is currently harvested most efficiently by non-mechanized techniques, making it suitable for small holders” (J. Hall et al., 2009, p. 583). Castor bean grows in a semi-arid climate where a lot of family farmers live. It is a rustic plant and relatively resistant to drought periods. Moreover, it allows the simultaneous cultivation of other crops (i.e. beans) which makes it very interesting for family famers because it goes well together with self-consumption farming.

In fact, after soybean castor bean has the second highest share amongst the raw materials acquired from family agriculture in most of the years between 2008 and 2014 (see Table 3). However, its share collapsed after a maximum in 2009 and 2010 and remains negligible compared to soybean.

Table 3: Acquisition of raw materials from family agriculture by type of crop in million R$

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Peanut	0.11	1.22	1.05	0.83	1.25	1.47	0.66
Rapeseed	0.62	0.35	1.17	1.9	1.78	0.79	1.13
Oil palm	2.45	2.5	3.35	-	-	-	-
Sesame	-	0.18	4.17	0.24	-	-	-
Sunflower	1.95	1.12	1.18	1.65	7.15	5.45	-
Castor bean	5.14	26.79	46.36	7.73	0.92	1.94	4.7
Soybean	266.25	645.19	1001.41	1506.82	2099.4	2845.52	3246.34

Source: SAF & MDA (2015)

Yet, castor bean plays no role in biodiesel production. In fact, there has not yet been any significant production of biodiesel from this crop in Brazil (Repórter Brasil, 2010a; Wilkinson & Herrera, 2010)[2]. Instead, the valuable oil extracted from this plant has been resold by Petrobras to the chemical industry which has offered higher revenues than Petrobras could get from biodiesel production (Kovac & Zimmer, 2012; Repórter Brasil, 2009; Wilkinson & Herrera, 2010). Nevertheless, it is promoted and purchased under the PNPB.

[2] Currently soybeans provide 70-85% of the raw material for the production of biodiesel. Despite the presently unfavorable conditions to use castor beans in the biodiesel production Petrobras as well as research institutions keep investing in technology, breeding and integration of more family farmers. Castor beans might be used as raw material for biodiesel in the future.

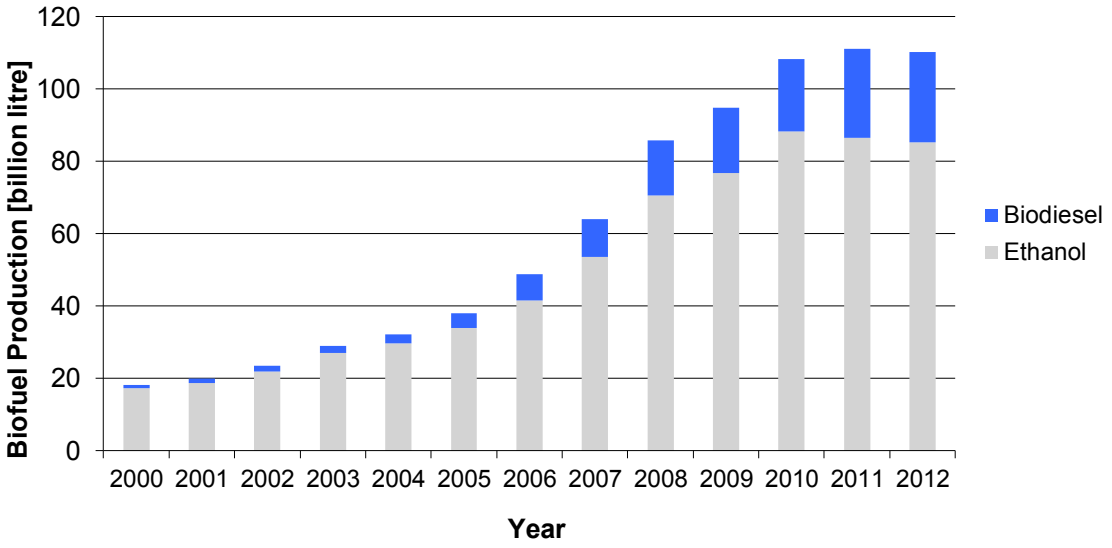
The implementation of the PNPB during the last years has been assessed by a range of authors (Brune, 2011; César & Batalha, 2010b; Faria, 2009; Garcez & Vianna, 2009; Watanabe & Zylberstajn, 2010). Several weak points have been identified, and a number of studies have questioned the success of the program. Several obstacles prevent the integration of more family farmers who produce different raw material into the program: i) their far-scattered habitation in a large area with insufficient infrastructure makes it difficult to access them; ii) past and current negative experiences with the production of castor beans prevent them from getting involved; iii) they are not used to contractual arrangements; iv) on the industry side there is little experience in dealing with family farmers (Watanabe, Bijman, & Slingerland, 2012); v) local conditions are neglected by the top-down-implementation of the program (Watanabe & Zylberstajn, 2010); vi) family farmers' culture and context are disregarded (Brune, 2011); vii) many farmers are inexperienced in working cooperatively; viii) their production process is inefficient; ix) they are over-indebted (César & Batalha, 2010b); x) climatic conditions in the semi-arid region are unfavourable; xi) technical attributes of castor oil are adverse for biodiesel production; and xii) technical assistance is insufficient. Abramovay and Magalhães (2008) furthermore expressed their fear that only the more prosperous family farmers will be able to take advantage of the PNPB. In 2006 the representation of the biodiesel producers' interests in Brazil *biodieselbr* proclaimed a high potential for biodiesel production in the country based on favourable climatic conditions and large areas of unused land (biodieselbr, 2006). This already shows that biodiesel was also seen as new opportunity for large-scale producers. The faster raise of the biodiesel blending quota caused by a high availability of soybeans from agribusiness as raw material points into the same direction. Also the dimension of the newly established biodiesel factory *Darcy Ribeiro Biodiesel Plant (DRBP)* in Montes Claros by Petrobras Biocombustível S.A. (PBio) in April 2009 indicates the direction of the journey: with a capacity of 152.9 million litres of biodiesel per year it needs to process oil crops from about 19 000 ha (Petrobras, 2016). This demand can only be fulfilled by the agribusiness (Laschefski, 2011).

However, the use of unproductive land for the cultivation of energy crops (e.g. soybeans, sugar cane) can cause unintended changes in other parts of the country. This is shown by the example of sugar cane expansion in the southwest of Minas Gerais and the south of Goias: farmers sold or leased unproductive pasture land and bought new land in the Amazon region (Laschefski, 2013). Also land reform plans are strongly effected: land that was previously considered unproductive and designated for land reform was made productive by using it for the cultivation of energy crops (Assis & Zucarelli, 2007). Thus, it was no longer available for land reform.

2 THEORY

2.1 Promises of biofuel production

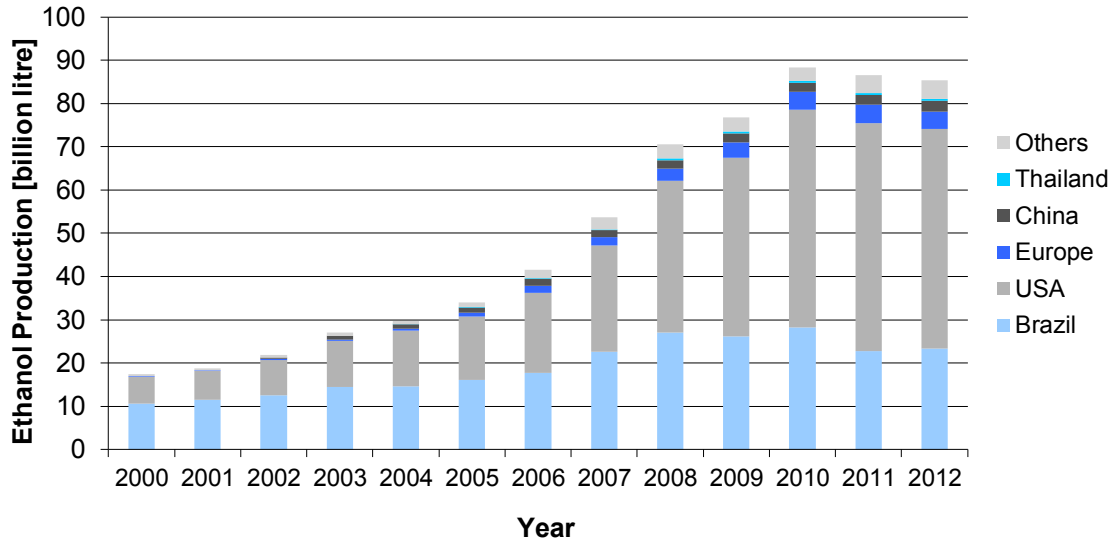
Since the beginning of the century the production of biofuels from different raw materials has increased in many parts of the world. The global biofuel production in 2000 totalled 18 billion litres and sextupled to 110 billion litres in 2012 (EIA, 2016). Ethanol accounted for 85 billion litres and biodiesel for 25 billion litres in 2012 (see Figure 6).



Source: EIA (2016)

Figure 6: Global biofuel production (2000-2012)

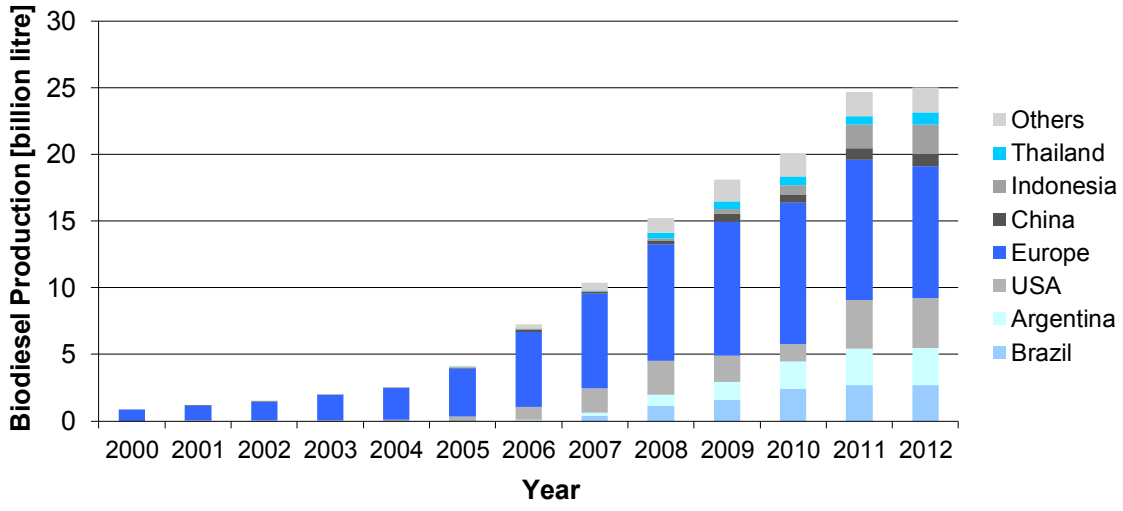
Main producers of ethanol are Brazil and the United States, who together cover almost 90 % of the market (Figure 7). Europe developed their position during the last years, and newly industrializing countries like China and Thailand are coming up too. The raw material used for the production varies depending on the region from sugarcane (Brazil), to maize (United States), and sugar beets and wheat (Europe) (WBGU, 2009).



Source: EIA (2016)

Figure 7: Global ethanol production (2000-2012)

For biodiesel Europe is the most important producer followed by the United States, and during the recent past Brazil and Argentina (see Figure 8). However, emerging countries like Indonesia and Thailand are increasing their share. The main raw materials for biodiesel are rape seeds (Europe), soybeans (USA, Argentina, Brazil) and palm oil (Asia).



Source: EIA (2016)

Figure 8: Global biodiesel production (2000-2012)

There have been three main reasons, subject to scientific discourse, for pushing bioenergy production in the past (WBGU, 2009). The first challenging topic is the mitigation of climate change which highly depends on the reduction of CO_2 emissions from fossil energy sources (IEA, 2011). It is hoped that bioenergy can contribute to climate mitigation and reduce the

emissions of CO_2 (WBGU, 2009). According to IPCC (2014, p. 26), “Bioenergy can play a critical role for mitigation”, but sustainability and efficiency of practices have to be considered.

A second reason for developing bioenergy systems further is the scarcity of resources like fossil oil or wood which contributes to a rise of energy prices. Rising oil prices already led to some serious crises during the 1970s. The overall tendency is that oil prices will stay volatile but will constantly rise because of rising demand, higher extraction costs and a continuing unstable political situation in the most important export countries. Bioenergy could lead to a higher security of energy supplies (WBGU, 2009).

Last but not least, rural development and economic potentials are expected to profit from bioenergy production (WBGU, 2009). Biofuel production and the integration of family farmers into the production chain in order to enhance their often precarious livelihood are seen as a glimmer of hope in many parts of the world. Especially emerging countries like Brazil see a high potential in an export-oriented production of energy crops and biofuel to create jobs and new income sources in rural areas (Silva, 2007). A growing world market is seen as a great potential by those countries (WBGU, 2009). Especially if energy crops are cultivated on marginal areas, this can have a positive effect on soil erosion and soil quality and the negative effect of being in competition with food crops can be avoided (BMZ, 2011). Summing up, the search is for win-win situations that provide income for farmers as well as for biofuel producers.

As was discussed at a meeting of energy experts from both developed and developing countries organised by the United Nations Department of International Economic and Social Affairs (UNDIESA) and the Food and Agriculture Organization of the United Nations (FAO) in Stockholm in January 1990, the supply of energy can help to alleviate poverty (Bhagavan & Karekezi, 1992). Any kind of energy is of great significance for the development process (Best, 1992). Renewable energy production can deliver both, a service and an economic option (Karekezi, 1992). On the one hand, an increased agricultural export is hoped for through the production of energy crops (Best, 1992), on the other hand, locally produced energy bears the potential to also be used locally (Best, 1992; Minott, 1992). The latter can lead to a higher energy autonomy and a support of agricultural production moving from subsistence to surplus production (Best, 1992). Minott (1992) argues that renewable energies are, in contrast to fossil fuels, by nature anti-monopolistic, more democratic and less centralized, which also makes their production vulnerable and expensive. These assumptions will be further verified in this research. As the conventional energy supply system has limits in the rural areas anyways (Karekezi, 1992), renewables can fill a niche if they are planned realistically and have reasonable objectives (Terrado, 1992). For example, diesel can be used for machinery in the mechanized agriculture, for transport, for agro-processing and the generation of electricity (Karekezi, 1992). A successful planning process includes the careful assessment of user needs (Mbewe, 1992) and the participation of the local community (Best, 1992; Karekezi, 1992;

Tinker, 1992). A typical reason for the failure of projects in the past has been the neglect of socio-cultural issues and the focus on technical issues exclusively (Minott, 1992). The idea is that subsidies are needed in the beginning to start the production, but to involve private investment as soon as possible (Karekezi, 1992) and thereby come to an economically self-sustaining solution. But it is also clear that many aspects can not be solved at the local level but have to be addressed by national policies: these are technical and techno-economic information, knowledge and training on technology functions, strengthening of local entrepreneurs and an in-depth understanding of local and national patterns of energy use and resource availability (Karekezi, 1992).

Despite these positive hopes some experts are rather critical towards their realization. Points of criticism most often mentioned are:

- A rising demand for energy crops and biofuels increases the competition for land (including dislocating rural people and forcing them to migrate into cities) (BMZ, 2011; Dufey & others, 2007; Misereor, 2011).
- The extended cultivation of energy crops diminishes the area for food crops and can lead to higher food prices to which poor people and small farmers are very vulnerable (BMZ, 2011; FIAN, 2008; Misereor, 2011).
- The cultivation of energy crops is mostly associated with large-scale production methods which tend to have little positive effects on rural labour (BMZ, 2011) or even squeeze small farmers out of the market (Dufey & others, 2007).
- The production of energy crops especially on large plantations may result in poor labour conditions (Dufey & others, 2007; Misereor, 2011) or even human rights violations (notably on sugar cane and palm oil plantations) (Dufey & others, 2007; FIAN, 2008).
- If international investors import their own work forces or just need highly specialized workers, the local population gains little from the investment (BMZ, 2011).
- Unequal power structures in an export-oriented production in developing countries may lead to unfair distribution of benefits in the upper parts of the value chain (Dufey & others, 2007).
- The dependence on very few international traders who are dominating the market bears the risk that primary producers will receive very few benefits (Dufey & others, 2007).

2.2 Paradigm of development through inclusion of farmers into value chains

Production, trade and investment are more and more organised globally. This globalisation implicates global value chains in which different actors are integrated in the production process. According to the World Bank a value chain is described as „the full range of value-adding activities required to bring a product or service through the different phases of production, including procurement of raw materials and other inputs" (Webber & Labaste, 2010, p. 9). Recently value chain development (VCD) became popular among governments, donors, and NGOs to stimulate economic growth, increase the competitiveness of the agricultural sector and to combat rural poverty (Donovan et al., 2015).

The integration of smallholders into agricultural value chains is a matter of discussion among scientists, politicians, development NGOs and donor organisations. Several hopes are associated with the inclusion of smallholders and family farmers into the value chain: e.g. tangible benefits in terms of economic performance (Donovan et al., 2015), poverty alleviation and entrepreneurship (Helmsing and Vellema, 2011; Franz et al., 2014), resistance to shocks and a higher productivity (Fan et al., 2013), improved livelihood, less vulnerable farmers, increased food security, predictable incomes and better health services (Vellema et al., 2013). The aim is to 'make markets work for the poor' and to „help the rural poor participate gainfully in local, regional and global trade" (Mitchell et al., 2009, p.1).

By looking beyond individual actors in the value chain (e.g. smallholders or cooperatives) and instead focussing on the whole value chain and the links between its actors it is argued that problems among actors can better be identified and win-win-outcomes be generated (Donovan et al., 2015). Development policy-oriented research institutions see the benefits of value chain analysis in a better understanding through which ways for a sustainable integration of farmers into (global) value chains and possibilities to strengthen the farmer's position compared to big companies can be found. With political and social instruments relatively powerless smallholders shall be empowered to assert their market interests against companies and governments (Mitchel et al., 2009; Hütz-Adams, 2012).

Not only NGOs and development agencies see a potential in value chain development but also companies who „look upon smallholder agriculture as a widely untapped resource for the sourcing of crops and as a sales market for agricultural inputs" (Franz et al., 2014).

Several case studies (e.g. Vellema et al., 2013; Franz et al., 2014; Mitchel et al., 2009) have been undertaken to evaluate how successful the integration of smallholders into value chains was (e.g. in Uganda, Rwanda, West Africa, India, Latin America). The outcomes are twofold. Positive as well as negative outcomes for smallholders have been documented. Positive outcomes were a higher productivity, better incomes and innovations (Ros-Tonen et al., 2015),

better interactions and trust between value chain partners (Vellema et al., 2013, Franz et al., 2014), transparent value chain processes, better financial and agricultural extension services, access to technology, better logistics, decreased information asymmetry and improved farmers' bargaining power (Franz et al. 2014). But scientists and practitioners also see the risk that existing inequalities and power imbalances between value chain actors might be reproduced (Ros-Tonen et al., 2015) because other examples documented only partial success. In a local food chain in Rwanda just well organised and networked farmers profited from the invented scheme and a larger group of farmers did not get access (Vellema et al. 2013). Examples from India and West Africa show that the industry partner profited more than the farmers who still take the risks and costs of negative externalities (Franz et al., 2014). Moreover, contract farming bears the risk of dependence on the contract partner (Dannenberg, 2013). Some schemes (e.g. Bayer's Food Chain Partnership in India and oil palm contract farming in the Brazilian Amazon) even exclude those farmers who have the highest need but are not compatible with the requirements of the value chain (Franz et al., 2014; Brandão et al., 2018). Instead, better educated and socially advantaged persons are the ones who participate (IAASTD, 2009). A loss of biological and dietary diversity was also found in some cases (Ros-Tonen et al., 2015). For Ros-Tonen et al. (2015) the integration of smallholders in international value chains seems to be at odds with principles of local production-consumption cycles and markets and autonomous energy, input and technology systems.

Smallholders who participate in value chain face several challenges: they have to meet certain quality standards, technical preconditions and logistics specifications and provide high volumes of a product (Fan et al. 2013, Franz et al., 2014). These criteria are often hard to fulfil for them and in addition they struggle with power and knowledge imbalances between them and the industrial partners and/or become dependent on those companies (Franz et al., 2014). Especially in large scale programmes and extensive value chains it can be difficult for smallholders to be heard in decision-making processes (Helmsing & Vellema, 2011). On the other hand companies who want to procure agricultural produce are also confronted with challenges: they "need to embed themselves into a business environment with which they are often unfamiliar" (Franz et al., 2014, p. 242). In general, actors in the value chain have different perspectives, values and meanings which can make a close collaboration in the value chain difficult (Helmsing & Vellema, 2011). Nevertheless, companies often determine the structure of a value chain and make the farmers a framing object which is included or excluded as they like (Franz et al., 2014). Helmsing & Vellema (2012, p. 8) state that "inclusion is mostly looked upon from the perspective of producer entrepreneurs and firms" which often impacts workers' rights negatively. According to them the focus has to be on *how* actors participate in economic networks rather than *if* they are integrated.

According to Schneider (2007) the agricultural modernisation process excluded many small holders and supported the most qualified farmers. Of course the exclusion of farmers can have strong implications on their economic possibilities. On the other hand farmers may choose not to be included in a certain value chain because they are included in another chain or network which might fit them better (Helmsing & Vellema, 2011). All these challenges can only be overcome with political, institutional and financial assistance. Also public private partnerships and smallholder friendly financing and investment are mentioned in this context (Fan et al. 2013, Franz et al., 2014). Several authors emphasize the importance of a favourable institutional environment in which the value chain is embedded for the success of small holder inclusion (Kilelu et al., 2017; Helmsing & Vellema, 2011). According to Helmsing and Vellema (2011) the contextual conditions, social embedding and policy measures which flank the value chain development can be very complex. Franz et al. (2014) also mention the often manifold and highly fragmented structure of agriculture and trade especially in the global South. Therefore, an analysis of the context or environment, in which the value chain is situated, is essential (Helmsing & Vellema, 2011; Mitchel et al., 2009; Donovan et al., 2015, Vellema et al., 2013).

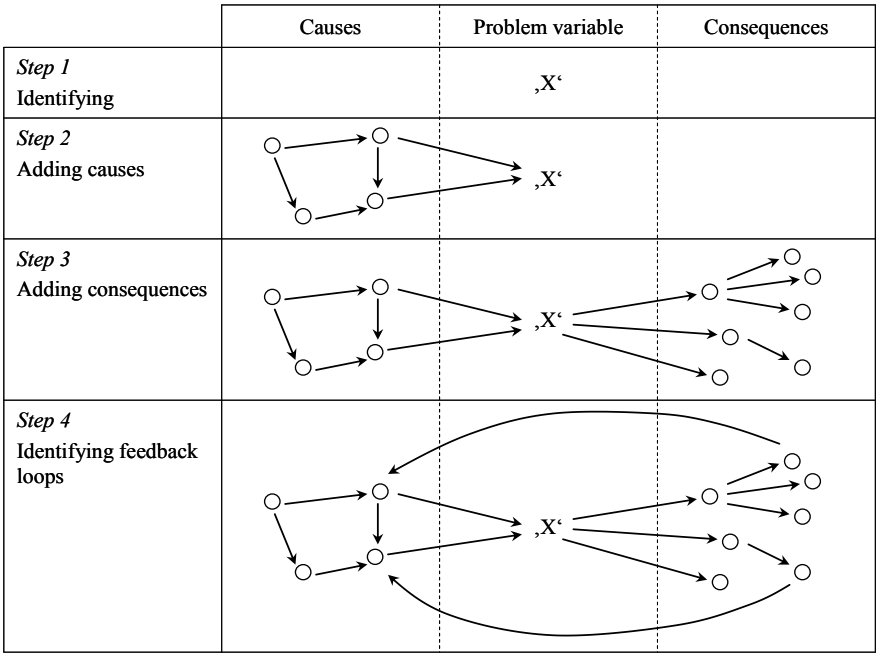
2.3 System Thinking

The System Thinking approach (Forrester, 1994) offers the possibility of reducing the complexity of real world systems, to make (polarised) interdependencies and dependencies between system elements explicit and thereby get a holistic view and improve the understanding of (social) systems. The boundary of the system encloses all relevant elements (variables) and their reciprocal interaction. Depending on the scope of interest it can be wider or more narrow, and it can change if the scope changes (Sankaran, 2010). In contrast to other approaches (e.g. Global Commodity Chain approach (Gereffi et al., 1994), Global Value Chain approach (Gereffi et al., 2005)) the System Thinking approach allows to incorporate the environment of the value chain into the analysis by defining a suitable boundary.

System Thinking provides the ability to understand how a system works and which “patterns of interaction and underlying structures […] shape the emergent patterns of systems behaviour” (Morgan, 2005, p.5). Senge (2014) describes System Thinking as a language to describe and understand the forces and interrelations that are responsible for a system’s behaviour. A System Thinking model can represent the real world including its complexity, interdependency, nonlinearity, and feedback loop structures (Forrester, 1994). By understanding the underlying structure the future development of the system can be analysed.

The analysis of causes and effects in a system is one important focus of System Thinking. The change of one system component affects other components: either this change happens in the same direction (a positive relation is marked with a '+') or in the opposite direction (marked with a '-'). The paradigm of feedback is another essential compound of System Thinking (P. Morgan, 2005). A complex system may have several feedback loops which lengthen the time gap between cause and effect. These feedback loops may aggravate an effect (positive reinforcing feedback loop) or diminish it (negative stabilizing/balancing feedback loop).

Causal Loop Diagrams are a central element of System Thinking. The tool displays the structure of a system by showing the variables, their interaction, and most important the feedback loops which are created by the interrelations. This tool enables a better understanding of the real world for the modeller as well as for the stakeholders (Sendzimir et al., 2010).



Source: Vennix (2001)

Figure 9: Building a Causal Loop Diagram in four steps

Figure 9 shows the development of a Causal Loop Diagram in four steps (Vennix, 2001). At first a *problem variable* is identified, then *causes* (other variables) that provoke the problem are looked for and added on the left side of the diagram. In a third step *consequences* that are induced by the problem variable are added on the right side of the diagram. During the last step possible feedbacks between variables on the consequences' side and variables on the causes' side are identified and added to the diagram.

2.4 Resilience

“The development of resilient agricultural systems is an essential topic of study because many communities greatly depend on the provisioning ecosystem services of such systems (food, fodder, fuel) for their livelihoods” (Altieri, 1999; in: Lin, 2011; p. 183).

An agricultural system linked to the production of biofuels must be tested for its resilience. Only if the system that results from the cultivation of oil crops for biofuel production is resilient it can survive in the long run and generate a sustainable livelihood for farmers.

In theory, there are different approaches to the definition of resilience. In ecology, resilience is defined as the ability or capacity of a system to absorb disturbances or changes and still maintain its structure as well as function and capacity for renewal and reorganisation (Folke, 2006; Holling, 1973). Resilience is also seen as the opposite of vulnerability (De Bruijne, Boin, & van Eeten, 2010). A resilient ecological system possesses self-correcting processes to respond to stress or challenges and restore pre-existing patterns (Kirmayer, Sehdev, Whitley, Dandeneau, & Isaac, 2009).

Resilience is a major concept not only in ecology but in psychology as well. Recently, it has become increasingly important in socio-economic systems, where resilience is associated with a measure of insurance to prevent change to a less productive state (Ranjan, 2012). A resilient community does not rapidly change in the event of disaster, returns quickly to a pre-disaster state and adapts to new circumstances (Kirmayer et al., 2009; Miles & Chang, 2011). In agricultural livelihoods, resilience is the capacity of a farm(er) to survive a severe economic or natural disturbance. Resilience also incorporates transformation and adaptation. Thus, resilience often results in positive outcomes that were not anticipated before the exposure to a risk (Fraser & Richman, 2001).

To apply the concept of resilience in practice, Christopherson et al. (2010) name some factors for a successful resilient system: innovation, learning region, modern infrastructure, skilled and innovative workforce, supportive financial system, diversified economy, high level of trust, high commitment work system, and supportive regional government.

In contrast to these concrete factors, Folke et al. (2003), Berkes (2007) and Darnhofer (2010) have a broader definition and list four relevant aspects to build resilience in social-ecological systems: (1) learning to live with change and uncertainty; (2) nurturing diversity in its various forms to increase options; (3) combining different types of knowledge and learning; (4) creating opportunity for self-organisation, cross-scale linkages and networks.

Darnhofer (2010) adapts these four factors for family farms and applies them at farm level: (1) A resilient farmer 'expects the unexpected', learns from failures, has an open mind for changes, is flexible and adaptive. Being able to use and recombine own resources and to keep debts at

reasonable level are other useful skills. (2) Increasing options through diversity means that a farm is characterised by a diversity of economic opportunities (e.g. different crops, on- and off-farm activities), a diversity of resources, communication partners, relationships and networks. (3) Referring to knowledge and learning a farmer should be able to combine traditional knowledge with own observations and scientific findings and to gather information from various sources and networks. Moreover, communication and social skills are important for business partnerships and the rural community. (4) Strengthening self-organisation and autonomy can happen through relying on own resources, the cooperation with neighbours (e.g. sharing of machines) and the installation of local networks and (nutrient) cycles. The provision of own energy (e.g. electricity from solar panels, heat from wood) makes farmers independent from other suppliers. Cross-scales linkages should be built with other stakeholders like the chamber of agriculture or farmers associations.

Beside these four aspects Darnhofer et al. (2016) analysed the current farm resilience research and classified the attributes associated with farm resilience into two categories: the attributes refer either to physical structures or social actors. As both perspectives have limitations they suggest a third one which brings relations between actors, the physical environment and among each other into focus. Depending on the perspective particular attributes are mentioned to be necessary for a resilient farm. Resilience research focusing on structures emphasises flexibility, diversity and a good connectivity with the context as necessary farm characteristics. Farm type and size, production practises and resource endowment are also taken into account although few specific recommendations are made because generalisation is difficult. In some studies social structures like markets, policies and labour availability are also integrated (Darnhofer et al., 2016). Overall, "[r]esilience is seen as resulting from the interplay of the dynamics within and between these structural features" (Darnhofer et al., 2016, p. 114). A clear relation between cause and effect is seen in this perspective (Darnhofer et al., 2016).

In the perspective focusing on social actors farmers are active agents who shape the process of change. Their values, believes and perceptions influence their actions that also base on the structural context but are not determined by it. As farming is socially constructed, learning capacity and social interaction play a crucial role in this context. Farmers different personal and social characteristics are reasons for higher or lower farm resilience but no clear, universal, causal if-then relations can explain this (Darnhofer et al., 2016).

As suggested by Darnhofer et al. (2016) a third perspective focuses on relations. In this perspective neither the physical farm nor the social farmer are in the focus but the activity of farming with all its context relations to physical and social structures. Farming is seen as a continuously changing not as a static process. As relations are continuously made and remade the focus is "on the relations and configurational patterns that enable on-going, creative and responsive change" (Darnhofer et al., 2016, p. 119) to new circumstances.

Based on the presented literature review it becomes clear that the assessment of farm resilience requires a broad approach which covers physical, social and relational features of the whole system. To assess the resilience of social-environmental systems different approaches exist: e.g. indicator based assessments (e.g. DasGupta & Shaw, 2015; Cabell & Oelofse, 2012), simulation models (e.g. Mumby et al., 2007; Rose, 2004) or life-cycle assessments (e.g. Pizzol, 2015).

Mathematical models often assume linear interactions, search for an equilibrium and underestimate uncertainties arising from tools or models (Darnhofer 2010). Thus, the prediction of future development must be somehow weak. Instead, resilience thinking changes the focus from predicting the future, seeking optimal states and modelling maximum sustainable yields to adaptive management and governance (Walker et al. 2004). The goal are not sophisticated forecasts and risk assessment methods but to enable a system to cope with surprise, allow for learning and increase adaptive capacity (Folke et al. 2002). Therefore, conditions are defined that limit or enhance these possibilities (Darnhofer 2010).

2.5 Research questions

Unemployment and poverty are two of the main problems in the Brazilian countryside. The implementation of the biodiesel program is driven by the motivation to overcome these problems through the incorporation of family farmers into market economy. The research question is: **Does the participation in the biodiesel program alleviate the precarious situation of poor family farmers in the north of Minas Gerais and make them more resilient?**

There are already some studies dealing with this topic that have revealed several problems in the implementation of the PNPB. However, the problem was not addressed completely. Thus, the current research pursues the existing research in the following way:

1. With the System Thinking approach the agricultural system that involves oil crop production under the PNPB is analysed in a systematic and holistic way.
2. Special focus is given to the actors, their mind sets, their concerns, their needs, and their communication.
3. The interplay between preconditions and the implementation and effects of the PNPB is analysed in detail.
4. With the investigation of strengths, weaknesses, opportunities, and threats (SWOT) it is evaluated how resilient the system becomes through the participation in the PNPB.

The system of biodiesel production in a rural area is very complex with all its different stakeholders, interdependencies and dynamics. The System Thinking approach makes it possible to holistically model the system and understand its interdependencies. Out of this the development of the system can be assessed in the course of time. The concept of resilience evaluates how sustainable the system will be in the long run. Resilience is an important factor for viability of family farms[3]. By combining the System Thinking approach with the resilience approach the research question will be assessed thoroughly and insights for a development towards a resilient family farming system will be gained.

This thesis is divided into three parts. Every part has a special focus and deals with specific questions:

First part:

- Who are the actors in the countryside with special focus on the PNPB and what are their mind-sets?
- What do they think of each other and how is their relationship?
- What are the important variables in the rural biodiesel complex and how are they interrelated?

Second part:

- How do preconditions influence the effectiveness of the PNPB?
- Who benefits from the PNPB?
- Which effects does the PNPB have on living conditions?

Third part:

- Are farmers able to negotiate on an equal footing with the industry side?
- Does the PNPB fit into family farmers' living reality?
- Does the participation in the PNPB make the family farmers more resilient?
- Can the PNPB contribute to rural development and social progress in the north of Minas Gerais or what could be alternatives?

To answer these questions, a set of methods is used. The System Thinking approach in combination with causal loop diagrams determines the actors, their mind-sets and communication structure. After this holistic view on the whole system, an in-depth field research is done in order to examine the concrete conditions in the two field study areas. All acquired data are then analysed by a SWOT[4] analysis.

[3] As the UNDP-Report 'Towards Human Resilience: Sustaining MDG Progress in an Age of Economic Uncertainty' (UNDP, 2011) emphasises, building resilience to economic and environmental shocks will be an important goal for a sustainable development. The report stresses that policies have to take effect on the household level of marginalised people.

[4] Strength, weaknesses, opportunities and threats

3 CONCEPT, STUDY AREA, AND METHODOLOGICAL APPROACH

The empirical part of this research was conducted within the framework of the research project *Biofuel as Social Fuel: Biokraftstoffe als sozialer Treibstoff einer nachhaltigen Entwicklung?*[5] in cooperation with the Brazilian research group GESTA[6].

To get an in-depth understanding of the situation and the effects of the PNPB in a rural area where family farmers produce raw material for biodiesel a case study was conducted in the northern part of the state Minas Gerais (*Norte de Minas*) (see Figure 10).

This area was chosen because of its social and geophysical conditions and can be described as structurally weak. As the focus group of the PNPB are predominantly underprivileged small and poor famers a region was identified where farmers already participate in the PNPB. Moreover the establishment of the biodiesel plant *Darcy Ribeiro Biodiesel Plant (DRBP)* in Montes Claros (which belongs to the biodiesel branch of the parastatal oil company Petrobras) was the starting point for biodiesel production in 2009 supported under the PNPB in this region. Hence, it was a good opportunity to attend the development of a new biodiesel complex and its effects in this structurally weak region. Castor bean (*Rizinus communis*) was chosen as researched crop because it promised to be very suitable for family farmers and their production systems (Abramovay & Magalhães, 2008) and it is grown by family farmers in this region.

[5] The research project *Biofuel as Social Fuel: Biofuels as a social fuel for sustainable development?* was funded by the German Federal Ministry for Education and Research (BMBF) within the program *Research for Sustainability* (FONA)

[6] Grupo de Estudos em Temáticas Ambientais (Study Group on Environmental Issues) situated at the UFMG (Federal University of Minas Gerais)

Source: Own representation based on GADM version 1.0 (March 2009)

Figure 10: Location of case study area Norte de Minas (Northern Minas Gerais)

After the first problem analysis, a second group of family farmers was identified as important for the production of biodiesel in Montes Claros. These family farmers are working jointly in a cooperative and farming mostly larger areas than the first group. They are growing soybeans which are very relevant as raw material for biodiesel production.

A differentiated analysis of the effects of the PNPB on family farming was done in the two municipalities Matias Cardoso (MC) and Chapada Gaúcha (CG) (for the geographical location of the municipalities see Figure 29 at page 36). Farmers in MC grow castor beans and farmers in CG grow soybeans. The two regions (CG and MC) are the main suppliers of their respective raw material (soybeans and castor beans) for the biodiesel plant in Montes Claros and were hence chosen as research areas. Although outer conditions for both systems are similar (both are incentivised through the PNPB), the inner structure (supporting and repressive factors) is quite different.

The north of Minas Gerais is characterised by a very dry climate and poor soils. The overall socioeconomic conditions are very unfavourable. Smallholders mainly raise meat and dairy cattle and grow various food and oil crops. For this region, the guidelines of the biodiesel program state that a minimum of 30% of the total industry agricultural expenses have to be related to family farmers in form of raw material purchase (oil seeds or vegetable oil), technical advisory service, seed distribution or transportation costs (MDA, 2009a).

3.1 Case study area Matias Cardoso

The municipality Matias Cardoso (MC) is located in the far north of Minas Gerais (see Figure 29, page 36). The total area comprises 1 949.738 km² and the population in 2013 amounted to 10 608 inhabitants. In 2006 the agricultural census counted a total of 850 farmers of which 723 or 85% are family farmers (see Table 4). Together they farm 112 043 ha, though family farmers own only 18.8% of the land (IBGE, 2014). In MC, farmers comply with the criteria of DAP and are considered family farmers if they do not own more than 260 ha, which equals four *módulos fiscais*. One *modulo fiscal* comprises 65 ha in MC.

Table 4: Agricultural structure in Matias Cardoso

	Number of agricultural businesses (units)	Number of agricultural businesses (percent)	Area of agricultural businesses (hectare)	Area of agricultural businesses (percent)
Family farmers	723	85.0 %	21 071	18.8 %
Non-family farmers	127	15.0 %	90 972	81.2 %
Total	850	100 %	112 043	100 %

Source: IBGE - Censo Agropecuário 2006 – Cidades@ (IBGE, 2014)

Matias Cardoso has a tropical savanna climate and belongs officially to the Brazilian *Semiárido* region. The average annual temperature is 24.5 °C and the average annual rainfall is 810 mm (Merkel, 2012). The climate is characterised by 6 month of drought on average (IBGE, 2010). The rainy season is between October and April. In MC the biome *Cerrado* borders with the biome *Caatinga* which is slightly nutrient-richer. The soil is a mixture of *cambisol*, *latosol* and *neosol.* It is characterised by a high content of iron and aluminium oxides and an acid milieu. The water conductivity is higher in sandy areas and the areas with a higher content of clay are more fertile.

The area belongs to the poorest regions in Brazil (Pochmann & Amorim, 2003). According to Costa (2007), the first colonial settlements date back to the 16th century. The population is comprised of migrants of European descent from different parts of Brazil, escaped African slaves, and indigenous people. From the 1970s until the 1990s *Ruralminas* (*Fundação Rural Mineira de Colonização e Desenvolvimento Agrário*) promoted colonisation and land tenure regularisation projects in the region, leading to the formation of many rural settlements in Matias Cardoso: Linha da Cruz, Linha do Campo and Barreiro I, II and III. Pieces of land (typically 25 ha) were sold for small amounts to the former informal occupiers of the place and also to farmers from different regions (G. M. Souza, 2012). All farmers were equipped with a small investment potential. The farmers cleared the land of trees and started growing crops such as common beans, corn, rice, cassava, vegetables, and fruits. The lots are small with high amounts of manual labour (see Figure 13 and Figure 16). Farmers are not organised in a cooperative, but are members of the local farmer's association, which provides machinery and functions as a loose aggregation of farmers who exchange ideas, knowledge, and sometimes strategies in acting jointly towards business partners or contractors. During recent decades, several governmental supported projects were attempted in the region to create new income sources for farmers, but all failed after a short time (e.g. cotton production, pig-fattening project). Since 2008, Petrobras and the technical assistance organisation EMATER[7]-MG have stimulated the production of castor beans as a raw material for biodiesel. Although no biodiesel is yet produced from castor oil, the numbers of farmers growing castor beans, and the associated cultivated area, have risen, with some interruptions, over time. Besides family farmers, several agro-industrial farms exist in MC, which mainly raise cattle and produce milk and meat. They own large pastoral areas, which have been enlarged during the recent years by buying land from smallholders. In this research, only family farmers were researched, because they are the only ones who provide raw material to DRPB.

Following Lamarche (1998), this group can be classified as family entrepreneurs (*empresa familiar*). These family farmers work in a traditional way, relying on family members, but already depend on a market to sell their products. They mainly use manual labour and rarely have employees. Figure 11 to Figure 22 show some impressions of family farming in Matias Cardoso.

[7] EMATER-MG (Empresa de Assistência Técnica e Extensão Rural do Minas Gerais) is responsible for the rural extension service in the north of Minas Gerais. They were a contract partner of Petrobras to promote the biodiesel program and to give technical advice for the cultivation of biodiesel crops.

Figure 11: Landscape in Matias Cardoso

Figure 12: Dried out castor bean field in MC

Figure 13: Harvest of castor beans in MC

Figure 14: Intercropping of castor beans and maize in MC

Figure 15: Castor bean plant in MC

Figure 16: Kitchen garden in MC

Figure 17: Pig farming in MC

Figure 18: Cattle farming in MC

Figure 19: Farm in MC

Figure 20: Small house in MC

Figure 21: Tractor in MC

Figure 22: Cattle drive with horses in MC

3.2 Case study area Chapada Gaúcha

The municipality Chapada Gaúcha (CG) is situated in the northwest of Minas Gerais (see Figure 29, page 36). It comprises an area of 3 255.187 km² with 11 972 inhabitants in 2013. During the agricultural census in 2006, 748 farmers were counted who farm 93 709 ha in total (IBGE, 2014). Family farmers comprise almost 87% of the farmers and own 28.6% of the agricultural land (see Table 5). Just like in MC, family farmers in CG are allowed to own 260 ha (four *modulos fiscais* of 65 ha each).

Table 5: Agricultural structure in Chapada Gaúcha

	Number of agricultural businesses (units)	Number of agricultural businesses (percent)	Area of agricultural businesses (hectare)	Area of agricultural businesses (percent)
Family farmers	650	86.9 %	26 822	28.6 %
Non-family farmers	98	13.1 %	66 886	71.4 %
Total	748	100 %	93 709	100 %

Source: IBGE - Censo Agropecuário 2006 – Cidades@ (IBGE, 2014)

CG belongs to the biome *Cerrado* and has a semi-humid climate with 4-5 month of drought (IBGE, 2010). The average annual temperature is 22.3 °C, the precipitation averages 1217 mm (Merkel, 2012). The soil is characterised as *latosol* (Universidade Federal de Viçosa, Fundação Centro Tecnológico de Minas Gerais, Universidade Federal de Lavras, & Fundação Estadual do Meio Ambiente, 2010), a typical nutrient-poor, acid soil with a high content of iron and aluminium oxides and a low water conductivity.

The municipality is geographically divided into two parts: the river banks and the plateau. Only family farmers on the plateau grow soybeans for the PNPB. While the river banks are traditionally cultivated, the colonisation of the flat and drier plateau began during the 1970s. In 1976 the first farmers arrived from the south of Brazil (Rio Grande do Sul) supported by PADSA, (*Projeto de Assentamento Dirigido a Serra das Araras*) a project created by *Ruralminas,* the agency for rural development. Culture and knowledge of these farmers developed and were transmitted over generations. It is believed that those settlers had a cooperative attitude to work because their ancestors were immigrants (Battilani & Schröter, 2012) and had to cooperate in the new environment to succeed. This is probably also why, in 1982, they founded the cooperative *Cooperativa Agropecuária Pioneria* LTDA (COOAPI), which had 250 members in 2013. The cultivation methods are intense and mostly mechanised (see Figure 24). The main goals of COOAPI are to provide their members with seeds and other required inputs, to provide technical assistance and to commercialise the production. The

planted area includes 15 000 ha of soybeans, 12 000 ha of forage seeds, 300 ha of corn and 200 ha of rice. Since 2009, around 80 % of the soybean harvest has been sold to Petrobras' biodiesel production plant DRBP in Montes Claros, while 20 % have been bought by other companies like Bunge, Cargill etc. According to Evandro Gobbi, the vice-president of the cooperative, 82 % of the members are family farmers and hold the family-farmer certificate known as DAP[8] which allows Petrobras to use the cooperative's soybeans to fulfil the quota of raw material purchased from family farmers.

The family farmers of CG are already integrated into the market. Following Lamarche (1998), this family farmers type can be classified as entrepreneurs (*empresa*). This classification implies a dependence on a market and a relative detachment of the traditional family farming logic. Figure 23 to Figure 28 give some impressions of agriculture in Chapada Gaúcha.

Figure 23: Landscape in Chapada Gaúcha

Figure 24: Harvest of soybeans in CG

Figure 25: Grass seed field in CG

Figure 26: Administration building of the cooperative COOAPI

[8] DAP = *Declaração de Aptidão ao Pronaf*. This document identifies family farmers or associated forms of cooperatives. It enables the holder to benefit from rural credit programs.

Figure 27: Farm in CG

Figure 28: Farm in CG

3.3 Other municipalities involved in the study

Besides the two main research areas Matias Cardoso and Chapada Gaúcha some other municipalities also located in the north of Minas Gerais were included into the research (see Figure 29).

Source: Own representation based on GADM version 1.0 (March 2009)

Figure 29: Location of research areas in Norte de Minas (Northern Minas Gerais)

Although MC and CG are the main suppliers of raw material for Darcy Ribeiro in Montes Claros the company also had contracts with family farmers from other municipalities. The experiences of these other farmers are very valuable to contextualise the results from MC and GG. Therefore farmers from the municipalities Taiobeiras, Montezuma, Rio Pardo de Minas and Varzelândia were invited for the workshops and except Varzelândia they were visited in the field as well. The geographical conditions are similar to those in Matias Cardoso. Table 6 gives an overview about the structure in all researched municipalities. Especially the average farm size varies between the municipalities.

Table 6: Other municipalities involved in the study

Municipality	Number of family farmers	Area of farms (ha)	Average area per farm (ha)	Modulo fiscal (ha)
Chapada Gaúcha	650	26 822	41	65
Matias Cardoso	723	21 071	29	65
Taiobeiras	962	27 387	28	65
Montezuma	903	16 973	19	65
Rio Pardo de Minas	2 873	54 664	19	65
Varzelândia	1 351	15 623	12	50

Source: IBGE - Censo Agropecuário 2006 – Cidades@ IBGE (2014) and INCRA (2013)

3.4 Concepts and methods

Due to the dynamic development of the research topic and area, no single method was sufficient. The growing understanding and knowledge during the empirical research period between 2010 and 2012 required flexible research instruments and the methods were adjusted accordingly. Hence, methodologic triangulation was chosen. This approach is a combination of several research methods and aims to secure an in-depth understanding of the researched topic (Denzin, 2012). The combination of multiple methodological practices, qualitative and quantitative strategies provides the potential to obtain meaningful information that might have been undiscovered with only one method. Thus, triangulation strengthens research results, gains complementary findings and enhances the completeness of data (Thurmond, 2001). Confidence in research data is increased, innovative ways of understanding the researched phenomenon are created, and the problem is clearer understood. The result is a more complete and holistic portrait of the studied phenomenon. Personal experiences and first-hand observations that include unpredicted and context-related findings, are an important part of the research (Jick, 1979).

This mix of methods enables a holistic view of the system because it integrates different sources of knowledge (stakeholder interviews, survey data, official statistics, empirical research, insights from other studies) and combines them into a conceptual model that represents and evaluates the important entities of the system and their dynamic interrelations. Figure 30 shows the general structure of the research process.

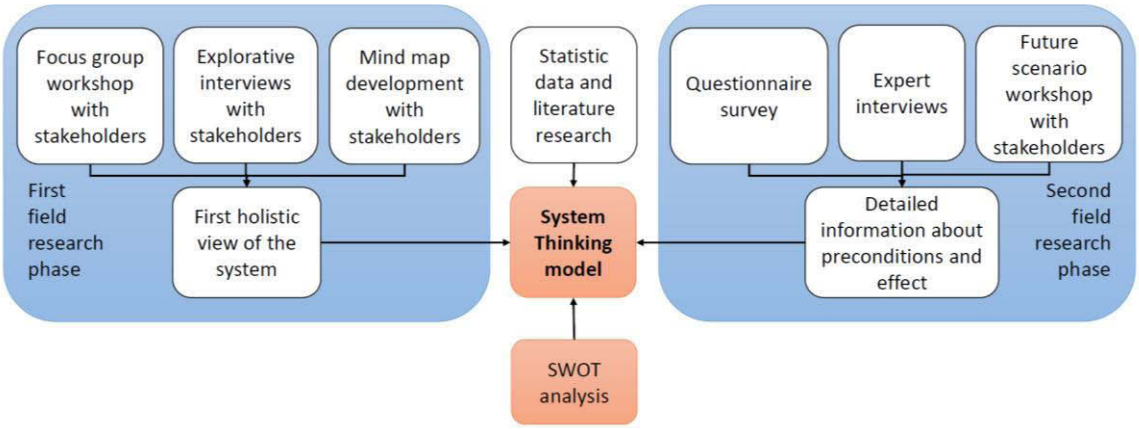


Figure 30: Research design

In 2010, two visits to the region around Montes Claros including MC were conducted. During the first visit, a focus group workshop took place with stakeholders involved in the PNPB. Thereby, a basic understanding of the structure and functioning of the agricultural systems that integrate oil crops into their production was gained. Throughout the second visit, explorative interviews provided the basis for the development of mind maps with stakeholders. The result was a first holistic view of the system (causal loop diagram).

To underpin the empirical findings, statistical data and literature were consulted. Different sources of statistical data were analysed in order to get the total number of family farmers in the research area and participating farmers in the PNPB including their distribution. Also, the statistical development of the PNPB, the structure of agricultural production, and yield data were determined from those sources. Simultaneously, a literature review was undertaken to compare the empirical findings with research studies from other regions. Information about the cooperative COOAPI in Chapada Gaúcha was of particular value, when during the research phase in 2010, it became apparent that this cooperative is another important contract partner for Petrobras in Montes Claros.

As official statistical data were not sufficient and did not have the required high resolution for a detailed picture of the agricultural systems in the north of Minas Gerais, a second research stay was organised. The research area was enlarged to Chapada Gaúcha. In 2012 family farmers in Matias Cardoso and Chapada Gaúcha were interviewed about their production systems, their preconditions and the effects of the PNPB in a semi-quantitative questionnaire survey (see chapter 3.4.4). The resulting data was contextualised by expert interviews (see

chapter 3.4.2) and field observations to get a holistic view of the system. To portrait of possible pathways, a future scenario workshop with representatives of family agriculture, technical assistance, and labour unions from the municipalities in the north of Minas Gerais was conducted. The analysis of this research phase displays a detailed picture of preconditions and effects of the PNPB in the north of Minas Gerais.

All collected data of this in-depth exploration were the basis for the System Thinking model (see chapter 3.4.3) of the agricultural system that integrates oil crops for biodiesel production. The conceptual model represents all important components (variables) of the system, their interrelations and shows the dynamics of the system. Based on the empirical data analysis, the initially planned System Dynamics model was not realisable and not appropriate any longer (more details see chapter 3.4.3). The resilience of the system was thus not evaluated through simulation of future scenarios but by analysing the structure of the System Thinking model and a SWOT (*strength, weaknesses, opportunities* and *threads*) analysis conducted with the variables of the System Thinking model.

3.4.1 Workshops

As a thematic introduction into the empirical research in Brazil, a focus group workshop was chosen. A focus group is a group interview that is guided by a moderator while the group is discussing the raised topic (D. L. Morgan, 1997). The aim is to stimulate a discussion which through its dynamic reveals information about the research topic (D. L. Morgan, 1996). This method is particularly useful, if the researcher wants to get a broad overview of the research topic and offers the chance to encourage stakeholders to express their views, questions, and priorities on the topic freely and in their own words. The advantage over a one to one interview is that people tend to explore and clarify their views in a group discussion more easily and often drive the discussion into new and unexpected directions (Kitzinger, 1995).

The workshop with 20 stakeholders was held in Montes Claros in May 2010. It was organised within the framework of the research project „Biofuel as Social Fuel: Biokraftstoffe als sozialer Treibstoff einer nachhaltigen Entwicklung?[9]“ in cooperation with the Brazilian research group GESTA[10]. Participants of the workshop were family farmers, advisors from technical assistance services, representatives of labour unions, agricultural administration, cooperatives, municipalities, and science. Geographically the following municipalities were represented: Matias Cardoso, Taiobeiras, Montezuma, Rio Pardo de Minas, Varzelândia,

[9] Biofuels as a social fuel for sustainable development?
[10] Grupo de Estudos em Temáticas Ambientais (Study Group on Environmental Issues) situated at the UFMG (Federal University of Minas Gerais)

Bocaiúva, and Coração de Jesus. Representatives of the biodiesel plant DRBP in Montes Claros were deliberately not invited to create a space where all participants and especially family farmers were encouraged to speak freely about their experiences. The presence of an industrial partner could have intimidated them.

During the workshop the participants shared their experiences with the biodiesel program. The whole group was divided into three focus groups which were moderated by one scientist of GESTA each. Six questions were asked by the moderator and discussed in the group:

1. Did you notice any change with the arrival of biofuels in your region?
2. Have you noticed any advantage for your region?
3. Do you consider that there are other uses for the raw material that is used for the production of biofuels? What is the best option?
4. How do you imagine the land you are working on in 10 years from now?
5. What do you wish for the future of your property / institution / entity and the region?
6. Imagine that you have the power to make decisions. What steps would you take for yourself and the region?

Afterwards, the answers were presented, discussed, and summarized in the whole group. In the end, strategies to ensure the advantages and to overcome shortcomings of the PNPB were discussed.

To take a look into the future, a second workshop was held in June 2012. The aim was to explore possible future scenarios for the regions. This future scenario workshop was organised within the framework of the same research project. The 15 Participants were local farmers, representatives of cooperatives, labour unions, agricultural administration departments, an agro-ecological research centre, universities, and the technical assistance service. The following municipalities were represented: Matias Cardoso, Chapada Gaúcha, Varzelândia, Taiobeiras, Rio Pardo de Minas, Montes Claros, and Coração de Jesus.

Methodologically the workshop was based on the scenario method described in the Field Guide to the future (Evans et al., 2006) and adapted to the research topic. The aim was to develop several future scenarios depending on the assumed conditions. With the scenario method participants were engaged in a mental exercise to explore possible future scenarios, preferences, and implications.

After a presentation of the research results generated in the period 2010 to 2011, including external forces influencing the situation of family farmers in the region, three possible future scenarios were discussed:

1. The biodiesel program continues in the same form as it is at the moment.
2. The biodiesel program ends.
3. The ideal scenario for the continuation of the biodiesel program.

The specification of these scenarios was done in three geographically homogeneous groups and shared and discussed with the whole group afterwards. Each group was moderated by one or two researchers from PIK or GESTA. Additionally the participants had the opportunity to share their personal perception of the current situation concerning the biodiesel program.

3.4.2 Interviews

To gather contextual information about and to get a holistic view of the agricultural system that participates in the PNPB semi-structured interviews with different stakeholders (family farmers, representatives of administrations, municipalities, cooperatives, extension services, universities, and members of oil processing companies) in the region were conducted. Beforehand, a list of questions to be asked was prepared. The topics comprised introductory questions about the organisation or farm, its structure and functioning, its role within the PNPB, its interrelations with other actors of the production chain, the operating principles, and the development of the PNPB (including problems and future prospects). The order of the questions was not standardised and flexibly adjusted to the interview situation (Flick, 2007). Moreover, the thematic focus of the interview was changed when information during the interview came up which required this. Thereby, the broadest possible information should be gathered. The interview partners were selected during the research process based on context related search for stakeholders in literature and internet and on the 'snowball' principle. All interviews took between half an hour to two hours (averaging one hour), were recorded and subsequently transcribed. The information gathered with the interviews contextualised the following research methods.

Table 7 gives an overview over participants of semi-structured interviews in 2010 and 2012. In total 23 guided interviews were conducted in 2010 and another 15 in 2012.

Table 7: Participants of semi-structured interviews in 2010 and 2012

Organisation	Name/municipality	2010	2012
Family farmers	Matias Cardoso	8	
	Montezuma	4	
	Rio Pardo de Minas	2	
	Taiobeiras	3	
Technical assistance service / cooperatives	EMATER	1	5
	COOPERSAM	2	
	Grande Sertão	2	1
	COOAPI		2
Oil processors	Petrobras - PBio Montes Claros	1	1
	Petrovasf		1
Administration	Ministry of Agrarian Development (MDA)		1
	Ministry of Agriculture in Montes Claros		1
	Secretary of Agriculture in Montes Claros		1
	Municipality of Chapada Gaúcha		1
	Municipality of Matias Cardoso		1
		23	15

3.4.3 Causal Loop Diagrams

To get a holistic view, the System Thinking approach was chosen. To identify linkages and feedbacks in the rural livelihood system, 10 interviewees have drawn individual mind maps (cause maps) in the way described in Vennix (2001) (see chapter 3.4.3). These mind maps show the problems connected to the production of raw material for biodiesel and the biodiesel production itself. Together with knowledge gained in the focus group workshop, during the explorative interviews, and from a literature review, the mind maps were used as the basis for the Causal Loop Diagram of the agricultural systems in the two study regions.

The mind-sets of the important actors in the agricultural system, which integrates the production of biodiesel, are a key element in understanding the interactions in this system. The manifestation of patterns, assumptions, principles, and paradigms in the mind influences the behaviour towards others. As in the system of biodiesel production different actors have to communicate with each other it is important to understand how they interact.

Of course actors can have very differentiated mind-sets. For this research it was especially important how they think about agriculture and biodiesel production. Another important aspect was their opinions towards the other actors in the system.

Beside the visualisation of mind-sets the purpose of the first piece of research was to get a better overview of the biodiesel production system. Therefore, mind maps were developed based on actors' mind-sets. The approach served several purposes:

- different mind-sets of actors became visible,
- actors could be categorized,
- main components of the biodiesel system were named and set into interrelation,
- through combination a holistic view on the system was developed,
- main obstacles observed by the actors became visible,
- expectations, foci, and past experiences appeared, and
- first ideas of why there could be communications problems were outlined.

Mind maps can be visualised as Causal Loop Diagrams. For the mind map interviews with stakeholders an example was used to demonstrate building a Causal Loop Diagram (see Figure 31). A different topic was chosen to not influence stakeholders' Causal Loop Diagrams.

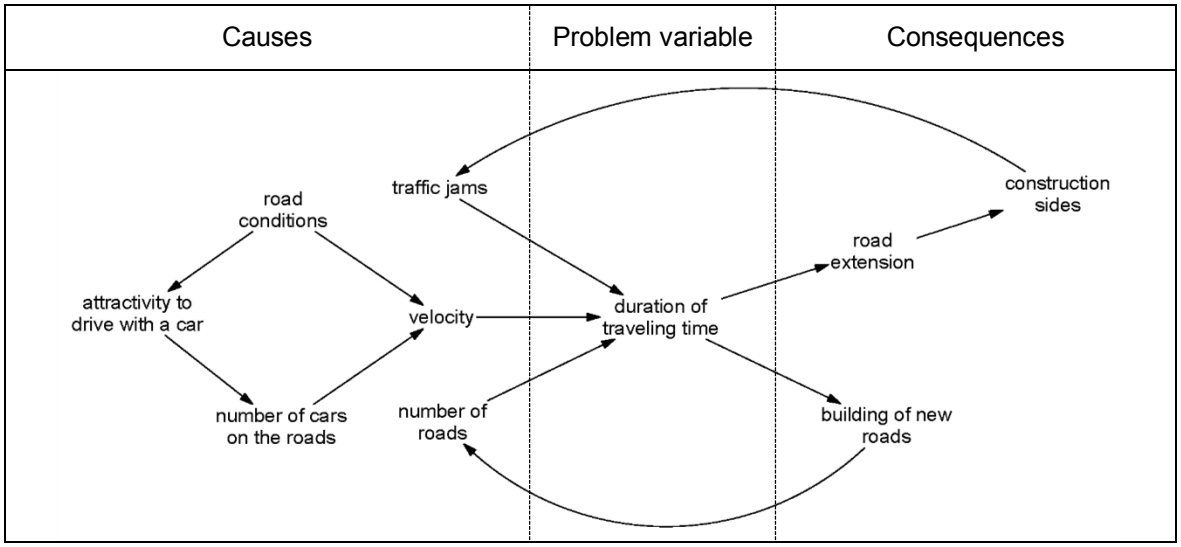


Figure 31: Example for a Causal Loop Diagram

To develop the Causal Loop maps 10 stakeholders were interviewed and asked to think of the biodiesel production and the main obstacles. During the interview the main problem (problem variable) was selected by the interviewer. The problem variables as a starting point of the diagram were either the cultivation or production of castor beans, the area of oil crops, the

production of biodiesel or value creation. All aspects associated to this problem and named by the interviewee were written as variables on small post-its either by themselves or by the interviewer (Figure 32 and Figure 33).

Figure 32: Mind map interview with a farmer

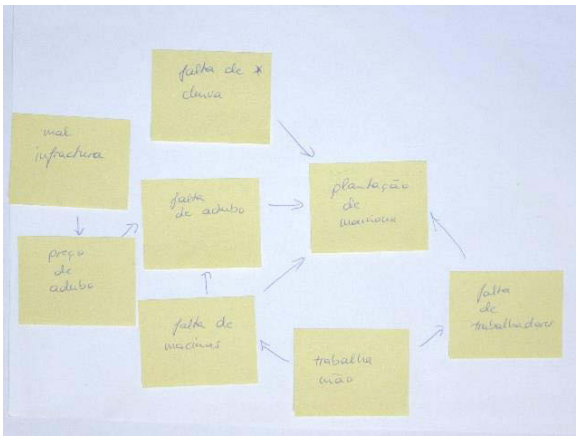


Figure 33: Causal Loop Diagram developed by a farmer

The interviewee was asked to connect the variables to the problem and to draw any interconnections they would see (cf. Vennix, 2001). Some unclear interrelations were clarified by asking back to the interviewee with a 'why'-question. Because some interviewees were not always easily familiar with the method, the cause maps were afterwards compared with the transcribed interviews and missing variables were added to the diagrams.

Afterwards, the diagrams were analysed in a semi-structured manner to find out which variables matter in the system. First, an aggregation and simplification of variable names was necessary because the interviewees did not always use the same wording, but from the context it could be known that they meant comparable aspects. The mentioned frequency of these variables was counted within the stakeholder groups and if the respondents emphasised the importance of certain variables this was taken into account as well. The outcome is a table which shows the ranking of three different stakeholders (or groups): Petrobras, the agricultural advisory service and the family farmers.

The cause maps were the basis for the subsequent System Thinking model which was further developed during the following research steps. Additional information was gained through field research and a questionnaire survey. This knowledge was used to refine the model.

Originally, it was intended to collect data in a questionnaire survey to further develop the System Thinking model and quantify its interrelations to build a System Dynamics model to simulate future scenarios. However, a convincing representative simulation model is extremely difficult to build for complex livelihood systems consisting of many qualitative variables and interrelations, in particular when data to calibrate the model are missing. In the case of family farming systems in Minas Gerais the young history of the PNPB has generated very limited

data and empirical evidence, which is insufficient for modelling. Furthermore, it became obvious that farmers faced a lot of problems between 2010 and 2012. Problems, uncertainties, and unexpected events are normality for the farmers, rather than a smoothly running system. This led to a highly unstable development and showed no clear pathway for the future. Moreover, the local farming systems targeted by the PNPB contain many qualitative variables and interrelations that are difficult to specify and, subsequently, to quantify. This incompatibility shows that it is far from an easy task to build a simulation model to assess alternative futures in a comprehensive way. Hence, the focus was shifted and it was decided to just build a System Thinking model and to further analyse it with methods described in the following chapters.

3.4.4 Questionnaire survey and assessment of living conditions

For the enhancement of the System Thinking model a deeper understanding of the agricultural production system including its oil crop production for biodiesel was substantial. The reality of family farmers living conditions and the following questions had to be examined:

1. What do family farmers produce?
2. Why do they produce these products?
3. How do they produce?
4. What do they earn?
5. What are their living conditions?
6. What difficulties are they confronted with?
7. What are the effects of the PNPB?

The living conditions needed to be understood before the effects of the PNPB on family farmers could be examined. Thus, a farm survey with a semi-quantitative questionnaire was conducted in the municipalities of MC and CG. The actual living conditions (including economic data, agricultural production methods, quality of life, decision-making, and personal evaluation of the PNPB) were researched by asking qualitative and quantitative questions. Based on examples of other household surveys a questionnaire was developed (cf. Ferreira, 2008; National Statistical Office, 2004; Schmitz & Castellanet, 1995). The questionnaire was pretested in an interview with a farmer in Chapada Gaúcha and thereupon adapted to the requirements in the field. To get a representative sample the participants of the survey were selected in accordance with experts of the local technical assistance. In total, 13 family farmers growing soybeans in CG and 29 family farmers growing castor beans in MC were interviewed. The interviews took between one and three hours.

The assessment of farmers' living conditions was an important goal. Therefore a definition of what is understood under the term *living condition* and a suitable method to measure it was needed. Human living conditions comprise factors like income, material prosperity or debt which are objectively measurable. Besides these factors they also include several aspects which are closely related to the terms "quality of life".

Excursus: Definition of quality of life

The terms "well-being" and "happiness" are sometimes used interchangeably with "quality of life". Other frequently used words in this context are "subjective well-being" and "life-satisfaction".

Veenhoven (2012) defines four qualities of life: *livability* (good living conditions), *life ability* (the ability to cope with problems of life), *utility of life* (outer visibility/meaning of life), and *satisfaction of life* (subjective enjoyment of life).

Quality of life is closely linked to the term "happiness" (Veenhoven, 2012). It is not easy to measure happiness. Respondents tend to mix up how happy they actually are with how happy other people think they are. Distortions are caused by ego defence and social desirability, and biases generated through survey design and the context in which the question is asked (Veenhoven, 2012). Often the subjective valuation of well-being differs from the objective well-being (Rojas, 2005, 2007, 2009).

Camfield (2012) suggests that the definitions of subjective wellbeing are *"culturally rooted 'moral visions'"* (p. 402). This explains why there are many different indices and methods for measuring well-being and quality of life and no universal method (Camfield, 2012); culture, gender, geographical area, and ethical issues all play a role for the subjective perception of well-being and quality of life.

In order to measure how farmers' quality of life and the environment are affected by the production of biofuels several authors have devised sustainability standards, criteria and indicators (Cramer et al., 2007; Fritsche et al., 2006; RSB, 2011; UN-Energy, 2007). These frameworks mostly consist of issues to be considered in this context rather than concrete measurable indicators. Such issues include land ownership, biodiversity, soil, water, air, food security, labour rights, health, income, and energy service.

As no standard method exists own indicators where defined. The focus lies on those quality of life issues mentioned in the biofuel sustainability discussion, especially social indicators. They

were adapted to the specific situation in the research area. The following set of subjective and objective indicators was used to measure quality of life in the north of Minas Gerais:

- production of food,
- labour conditions,
- material well-being (income, wealth, debt),
- economic risk,
- family,
- education,
- health,
- land ownership / land prices,
- personal subjective assessment of life satisfaction, and
- future prospects.

The assessment of living conditions was required to estimate the effects of the production of oil crops on them. There exists a bidirectional dependence:

1. The production of oil crops affects the living conditions and
2. the living conditions influence the possibilities to grow oil crops.

Besides these interdependencies living conditions are also influenced by history, culture and tradition. The production of oil crops is influenced by the legislation (PNPB and general policies), weather/climate and structural changes (e.g. agrarian reform). Figure 34 illustrates these interdependencies.

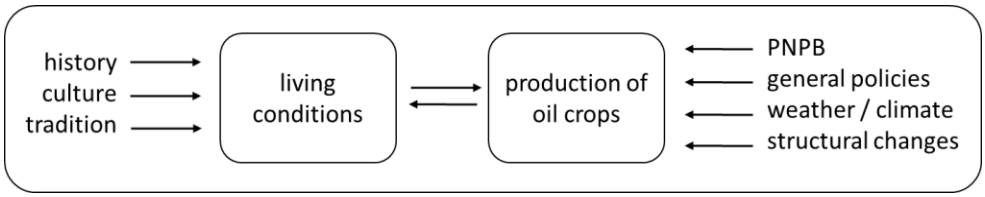


Figure 34: Interdependencies in the system of living conditions and oil crop production

The analysis of the questionnaire survey took place in several steps. First the answers had to be digitalized into the analysis software SPSS. After the dataset was created different calculations were done like mean values, sums, etc. Following indices were calculated to represent the income and wealth situation:

- *Agricultural farm income per person* is the net profit of all agricultural activities within one year divided by the number of people living in the same household. Subsistence agriculture was not accounted for, although it is an important non-monetary income source.
- *Total income per person* is the income including transfer payments by the government (pensions, social welfare, etc.) and income from non-agricultural work. This was also calculated over one year divided by the number of people living in the household.
- *Debt per person* is the value of loans taken from banks, other institutions or private persons. To make it comparable all values are given per person.
- *Wealth* was calculated according to the classification used by the Brazilian Association of Research Companies. In this classification, there are eight socioeconomic classes – A1, A2, B1, B2, C1, C2, D, and E, where A1 is the highest and E the lowest class[11] (ABEP, 2012).

The economic risk taken by the respondents was measured through a diversity index which has values between 0 and 1, where 0 stands for no diversity (only one source of income) and 1 for the highest diversity. *Simpson's diversity index of revenue* (Simpson, 1949) which is used by Florin, van Ittersum & van de Ven (2012) in a similar context is defined as follows (Eq. 1)

$$\text{Diversity index} = 1 - \sum_{i=1}^{n} l_i^2 \qquad \text{(Eq. 1)}$$

Where *l* is the fraction of total revenue of activity *i* and *n* is the total number of activities.

This diversity index only measures cash crops and animal products, but in Matias Cardoso self-consumption agriculture continues to play an important role. Farmers produce a lot of food crops for their own use or for animal fodder, and so a second diversity index was calculated for Matias Cardoso that includes self-consumption agriculture. Sold and self-consumed products were accounted for in this index and subsistence crops were estimated from the total production and market prices in Brazil. Animal products were incorporated by taking the value of the animal divided by its average lifetime.

Besides the calculated indices an enhanced System Thinking model for the two agricultural systems in MC and CG was a result of the field research.

[11] The classification is based on the number of selected possessed items. These items are multiplied with a factor. The sum of all points per household determines the economic class of that household. Annex 2 lists items, factors, points, and classification key.

3.4.5 Resilience and SWOT analysis

To evaluate how resilient the two in depth researched agricultural systems that participated in the PNPB and integrated oil crops into their crop system are, a resilience analysis was conducted. Kirmayer et al. (2009) recommend using the holistic models of systems theory to evaluate resilience. They see a close connection between the holistic view used by System Thinking and resilience. According to them, the analysis of dynamic circles and feedback loops is essential for the evaluation of resilience. Positive feedback loops can reinforce disturbances and hence destabilise the system. Negative feedback loops, however, can function as balances (Forrester, 1994). According to Kirmayer et al. (2009) a resilient system contains feedback loops that seek and maintain a steady state or balance. The fewer positive and the more negative feedback loops a system contains, the more resilient it appears to be. Shocks, disturbances, stresses, uncertainties and surprises can originate in the system or they can come from outside (for example a change of a governmental program). Thus, the System Thinking model, which sets ecological, social and economic components of the farm system into relation, built the basis for the resilience analysis.

To not only evaluate the structure but also the variables of the System Thinking model a SWOT analysis was carried out. The SWOT approach identifies the *strengths, weaknesses, opportunities* and *threats* of the system of interest. Originally, it was applied to business ventures and in strategic management but it can also be used to analyse social and environmental systems of a wider range (see e.g. Nouri, Karbassi, & Mirkia, 2008; Sanagustín Fons, Fierro, & Patiño, 2011; Sharma & Bhatia, 1996; Terrados, Almonacid, & Hontoria, 2007) or to support land use planning (Fürst & Scholles, 2008). Generally, the analysis is conducted in relation to the objective a system develops or 'wants to reach'. Thus, the agricultural systems were evaluated towards the ability to stay or become resilient while integrating oil crops for biodiesel production into the crop system.

The analysis comprised the core agricultural system, which is determined and influenced by the farmers themselves, and the external biodiesel production chain, which cannot be influenced directly by the farmers. The whole system is resilient if it can provide a sustainable livelihood for the family farmers. External and internal factors that either help or hinder achieving this objective are specified and can be shown in a SWOT matrix (Houben, Lenie, & Vanhoof, 1999). This matrix is an illustrative visualization for stakeholders as well as scientists. The SWOT matrix can be divided twofold into an upper and a lower part and into a right and a left part (Figure 35).

	Helpful factors	Hindering factors
Internal factors	Strengths	Weaknesses
External factors	Opportunities	Threats

Figure 35: SWOT matrix

Relating to the agricultural system strengths and weaknesses (upper part) are considered to be internal variables of the core agricultural system itself. They can be seen as indicators for resilience and stability (cf. Christopherson, Michie, & Tyler, 2010). The more variables are in the upper part – integrated into the core system – the more influence farmers have on their fortune (cf. Houben et al., 1999). Opportunities and threats (lower part) are classified as external variables, which are not part of the agricultural system that can be directly influenced by the farmers (cf. Hill and Westbrook (1997) who define these categories for a firm). These variables indicate the probability of unexpected external changes (Holling, 1973) coming from outside the local agricultural system.

Variables on the left part of the matrix are advantages and make the system strong against disturbances (*strengths*) or can be seen as external chances (*opportunities*). The more variables are listed on the left-hand side of the SWOT-matrix, the stronger the system appears to be. The right-hand section comprises limitations of the core system (*weaknesses*) or variables that derogate the core system and are not able to be influenced by the farmers (*threats*).

With the knowledge gained by the explorative research in the two case study areas, the variables of the System Thinking models were evaluated as *strengths, weaknesses, opportunities* and *threats* based on the recent history and actual development (similar to Sanagustín Fons et al., 2011). The result is shown as coloured variables in a System Thinking model as well as in a SWOT matrix. To all involved variables equal weights were assigned as they cannot be ranked without entering large uncertainties or subjectivity into the analysis. This means no variable is more important than any other. This is possible because the System Thinking model is restricted to showing relevant variables, and no variable can be subsumed under another.

The distribution of the variables in the matrix gives guidance on how resilient the system appears. The SWOT categories are evaluated as follows:

- *Strengths*: Strong positive influence on resilience; helpful factors that must be tested for flexibility, for that they do not stabilise the system instead of improving the resilience (see Holling, 1973).
- *Weaknesses*: Negative influence on resilience; can be influenced by the actors in the core system.
- *Opportunities*: Positive influence on resilience; can be used but do not need to be used.
- *Threats*: Strong negative influence on resilience; cannot be influenced by the actors in the core system and are hence dangerous; some threats can trigger the system to remain flexible and react to disturbances (again Holling, 1973).

The best combination for a resilient farming system would be as many internal *strengths* and as few external *threats* as possible.

3.5 Integration into the discipline geography

The discipline Geography with its subareas physical geography, human geography and regional geography (Leser & Schneider-Sliwa, 1999) is characterised by a high degree of interdisciplinarity. The assessment of space-related data is a major focus of geography. Empirical data collection is especially important in the field of applied geography. These principles are applied in this thesis. Studying human-environment-relations in regional or local case studies is typical for geography. Therefore, for example space-related interaction models and local networks are examined (Haggett, 1983).

Understanding global phenomena is not possible without the assessment of local conditions and impacts. This thesis contributes to a better understanding of local impacts of a global trend (production and use of biofuels) and a nationwide policy (Brazilian biodiesel program).

Modern geography follows a holistic approach and applies a system view at the research topic (Leser, 2006). For the analysis of a complex and dynamic system often model building (like System Thinking) and simulation are used as tools (Bossel, 2004). Therefore interrelation and dependencies between system elements as well as ecological, economic and social aspects are taken into account. The combination of qualitative and quantitative data and different model types, which is also used in this thesis, enables a holistic assessment.

As geography stands in the tradition to evaluate systems in the context of sustainability the resilience analysis of this thesis relates to this field. For this thesis the focus of assessment was laid on the social and economic factors of the system because the biodiesel program also had this focus. Nevertheless, the ecological conditions are the basis for the system and are thus integrated into the research.

4 MIND MAPS OF BIODIESEL ACTORS

4.1 First approach to the topic: Focus group workshop

During the focus group workshop farmers, labour union members and agricultural advisors shared their first experiences with the biodiesel program. During discussions in three smaller groups they had the opportunity to express their opinions which were later presented to the whole group. Moreover, they exchanged their experiences with members from other municipalities. Although the experiences differed between the regions a consensual view on the expected positive and negative effects of the biodiesel program could be formulated. The outcome was visualised in two diagrams: one shows the positive effects (Figure 36) the other one shows the negative effects (Figure 37).

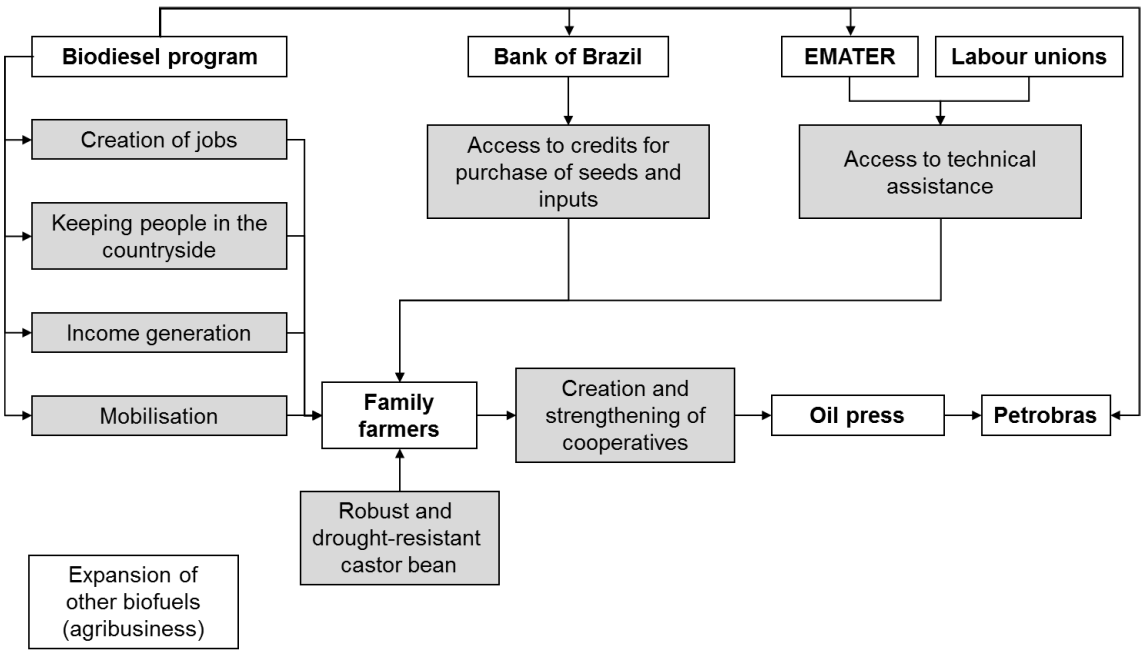


Figure 36: Expected positive effects of the PNPB (Laschefski, 2011; own translation)

The following positive effects were seen by the stakeholders: The biodiesel program involves several stakeholders with different functions. The Bank of Brazil provides credits for the farmers, EMATER and labour unions support and advise the farmers technically and Petrobras is the main institution in charge to implement the PNPB and processes the oil seeds to the end product biodiesel.

Besides the positive valued access to credits and technical assistance the most important expected positive effects are the creation of jobs and the generation of income. The cultivation of castor beans provides a new income source and thereby offers the opportunity to stay in the

countryside instead of moving to a city to get a job there. Through the biodiesel program family farmers are mobilised (mostly through the agricultural advisory service by the initiative of Petrobras) and integrated into the economic cycle which they value as positive. This boosts their self-confidence because they feel important for the production of fuel. Petrobras as a more reliable business partner than the middleman to which family farmers sold their production prior to the biodiesel program offers economic safety. Generally the farmers count very strongly on the support of governmental programs. They see the government in charge of providing income alternatives and act for a bettering of their economic and social situation. Besides economic effects the biodiesel program also has social effects, e.g. the expected creation and strengthening of cooperatives is a valuable outcome and requirement for the functioning of the program. Castor bean is a convenient crop for family farming because it is a rustic crop which is able to survive drought better than other crops, it is harvested by hand, it has a shorter production cycle than cattle and it is applicable for mixed cropping.

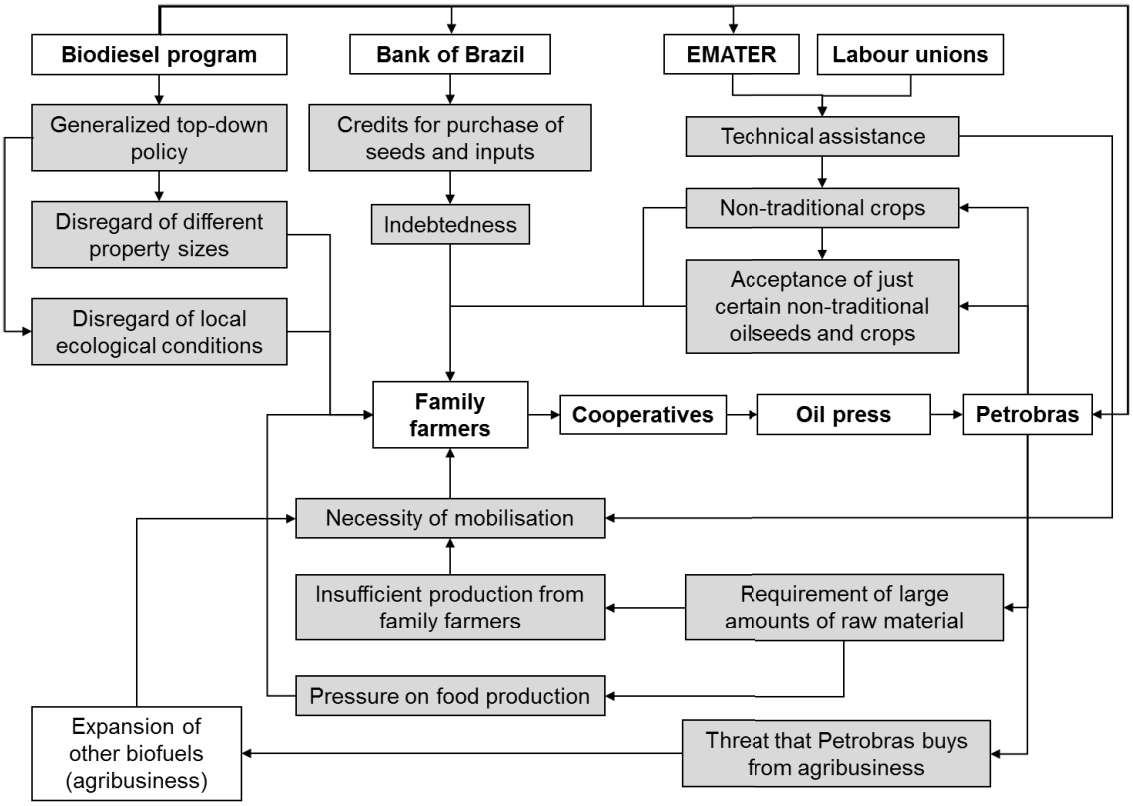


Figure 37: Expected negative effects of the PNPB (Laschefski, 2011; own translation)

Besides the positive effects a lot of negative aspects came up during the workshop (Figure 37). Criticism was especially directed at the top-down approach of the biodiesel program which neglects local ecological and social conditions and property sizes. Partly, seeds were developed in and for other regions and are not compatible in northern Minas Gerais.

The potential of getting credits from the bank to buy seeds and other inputs also bears the danger of debt. Moreover, some farmers have difficulties to get a loan because they are already overindebted or have difficulties to fill out the required forms.

For each region certain oil crops are promoted by the biodiesel program. Castor bean is chosen for northern Minas Gerais. Besides its value as oil crop it has a toxic effect on cattle. Macauba palm as a native oil seed in northern Minas Gerais is excluded because it does not offer large amounts of raw material in short time. This top-down approach disregards local conditions and was criticised. It also bears the risk of monocultures. Furthermore, family farmers expressed the concern to serve larger economic interests which was not what they intended.

Not only the crop is specified but also only one seed variety is provided by Petrobras. Furthermore, oil seeds take over fields and repress the production of food which cannot grow on the same field. This can lead to pressure on food production.

Although family farmers are mobilised and motivated to grow oil crops, the production might be insufficient. The requirement of large amounts of raw material might then be satisfied by the agribusiness. Family farmers feared that they would be crowded out of the market.

Some farmers already questioned the success of the biodiesel program and the guaranties provided by Petrobras. They felt an uncertainty concerning the contracts as Petrobras gave uncoordinated information and already broke the contract when they did not provide seeds for the sowing in time. Another insecurity arose from the fact that Petrobras was the only reliable buyer of castor beans in the region which made the farmers very dependent on this contract partner. But Petrobras also depended on the family farmers because without buying their raw material they would not get the *Social Fuel Seal* and the linked tax reductions. Moreover, family farmers had no share in the processing of the castor beans because Petrobras only bought raw material. Oil being the only intended purpose of castor beans restricted the use and was another obstacle for the farmers.

Castor bean as a new crop for many family farmers demands machinery for the sowing and pesticides during the growing. Machines are not always available in adequate quantity and pesticides have to be bought.

All in all, representatives from the municipalities Varzelândia and Matias Cardoso evaluated the biodiesel program more positive than participants from Taiobeiras and Montezuma. Reasons for that were soil quality, climatic conditions, property sizes and former experiences.

The participants of the workshop did not only identify the pros and cons of the biodiesel program but also explained their common desires associated with the agricultural production. The following wishes were expressed by different stakeholders for several times during the workshop:

- education and information (i.a. concerning conservation purposes) are essential,
- public policies and incentives should be extended[12],
- added value through processing of the raw material (oil pressing and use of the husk) is desired,
- a second market for oil seeds would be good,
- even better than the cultivation of oil seeds would be the cultivation and processing of sugar cane because it is already better known,
- a diversity of cultivated crops must be ensured,
- partnerships, cooperation, and the building and strengthening of networks and cooperatives is crucial,
- bottom up approaches are preferred to top down approaches,
- family farmers' self-responsibility and independence are important and have to be strengthened,
- family farmers and their work have to be acknowledged,
- family farmers need more land,
- infrastructure and public health system have to be improved, and
- agrarian reform must be pushed forward.

4.2 Foci, problems, and strategies in 2010

In the system of oil crop production different stakeholders are important. They can be clustered into three groups: farmers, agricultural advisors, and biodiesel producers. These actors all have a varying sight and problem perception on the on the biodiesel system and the most pressing problems concerning biodiesel production from castor beans.

The analysis of the mind maps created by farmers (from Matias Cardoso, Rio Pardo de Minas and Montezuma), agricultural advisors (EMATER, COOPERSAM and Grande Sertão), and the biodiesel producer (Petrobras) in 2010 shows, that different stakeholders have an overlapping but not identical view on the system. Table 8 gives a differentiated picture and shows the

[12] Public incentives and subsidies always bear the risk of becoming dependent on these measures (cf. Myers & Kent, 2001).

ranking of the importance of the aggregated variables. The importance was evaluated by the frequency with which each variable was mentioned in all mind maps.

Table 8: Importance of variables according to stakeholder groups (indicated by number of stars)

Petrobras		**Technical assistance service**		**Family farmers**	
Production of castor beans	***	Production of castor beans	****	Production of castor beans	*****
Technical assistance	***	Machinery	****	Machinery	*****
Mobilisation	**	Tradition/experience	****	Soil quality	****
Machinery	**	Income	***	Fertilizer	****
Cooperative	**	Guaranteed price	***	Weather/climate	****
Infrastructure	*	Assured profit	***	Infrastructure	****
Assured profit	*	Financing	***	Transport/logistics	****
Transport/logistics	*	Soil quality	***	Financing	***
Contracts with Petrobras	*	Availability of seeds	***	Credits	***
Trust	*	Trust	***	Availability of seeds	***
Weather/climate	*	Other markets	***	Contracts with Petrobras	***
Fertilizer	*	Technical assistance	***	Technical assistance	***
Workers		Transport/logistics	**	Income	**
Education		Contracts with Petrobras	**	Assured profit	**
Soil quality		Fertilizer	**	Sowing date	**
Bureaucracy		Weather/climate	**	Material aid	**
Attributes of castor beans		Breach of agreement	*	Workers	**
Income		Bureaucracy	*	Education	**
External support		Credits	*	Tradition/experience	*
Financing		Risk of overindebtedness	*	Bureaucracy	*
Guaranteed price		Attributes of castor beans	*	Risk of overindebtedness	*
Credits		External support	*	External support	*
Quality of life		Infrastructure	*	Attributes of castor beans	*
Material aid		Cooperative	*	Cooperative	*
Sowing date		Quality of life	*	Quality of life	*

Petrobras	**Technical assistance service**	**Family farmers**
Availability of seeds	Workers	Mobilisation *
Tradition/experience	Education	Breach of agreement *
Risk of overindebtedness	Material aid	Trust *
Breach of agreement	Mobilisation	Other markets *
Other markets	Sowing date	Guaranteed price

As the pure list of important variables gives an impression about the topics that are important to the different actors it does not say much about the evaluation of these topics. Therefore some context that was gained during the interviews will be given.

The main businesses of the industrial partner Petrobras are the exploration, extraction, processing, and distribution of mineral oil and gas. The company had no experience in working with farmers especially with small family farmers before they were involved with the PNPB. From their perspective the main obstacles for an economically functioning biodiesel production chain are: the distribution of the farmers over a large area, their low mechanization degree, their unwillingness to organise themselves in cooperatives and the resulting difficulties in organising logistics, technical assistance, inputs, contract closing, and support supplemented by an insufficient infrastructure (Petrobras, 2010). The following interview excerpt underlines this:

> *"Now if Petrobras is going to buy there from the big business or the family farmer, it is up to the family farmer to be structured and able to produce that oil, and at least 30% I will have to buy from the family agriculture if I want to keep the Social Fuel Seal."* (Interview with the representative of the Darcy Ribeiro Plant, in Montes Claros – MG, May 5, 2010, quoted from Ramos (2011, p. 51), own translation)

Additional challenges for a functioning biodiesel chain are weather and climate conditions and insufficient trust. According to Petrobras of foremost importance in the system (besides the production of castor beans which was mentioned by everybody) is the technical assistance service (financed by Petrobras) which acts as a middleman between Petrobras and the family farmers.

According to a representative of the biodiesel plant Darcy Ribeiro in Montes Claros (Petrobras), the easiest way to get raw material from family farmers is to buy it from cooperatives like COOAPI in Chapada Gaúcha:

> *"Well, soy is also from family farming ... and has been crushed since the beginning of the year 2010 [...] In the issue of soybean we also have no difficulties because it is a structured chain [...] The produced quantity, the employed technology, everything in that sense so, up to the price mechanism, you have a stock exchange of soy. [...] To give you an idea of the soybean cooperative [COOAPI] in one year, it delivers 30,000 tons of soybeans in one year."* (Interview with the representatives of the Agricultural Supply Management of the Darcy Ribeiro Plant, in Montes Claros - MG, November 03, 2010 quoted from Ramos (2011, p. 81), own translation).

The representatives of the technical assistance service mentioned similar variables as the family farmers (see Table 8). They emphasised the economic benefit for the farmers but also underlined the preconditions that must be fulfilled in order to successfully take part in the program as a raw material supplying farmer (i.e. sufficient machinery, experience, financing possibilities, a reasonable soil quality, availability of seeds, trust, and technical assistance). If these preconditions are not given each of them can convert into an obstacle for the production of castor beans.

As the technical assistance service was provided by different organisations in the area (EMATER, COOPERSAM and Grande Sertão) these organisations had a slightly different opinion as well. They all entered into contracts with Petrobras but faced several challenges. Most difficulties occurred in the collaboration between Petrobras and Grande Sertão. According to Aparecido from Grande Sertão (Grande Sertão, 2010) the cooperative started a project with Petrobras in 2007 (even before Petrobras built the biodiesel factory in Montes Claros in 2009) with 3 600 family farmers. This first project should have run over three years and after two years of raw material supply to Petrobras Grande Sertão wanted to deliver extracted oil. Through processing of raw material an additional value creation for the farmers should have been realized. With the building of the biodiesel factory in 2009, Petrobras changed its strategy and just wanted to buy raw castor beans. This was considered as breach of contract (dos Santos et al., 2011). In 2010, Grande Sertão had a new contract over technical assistance with Petrobras. Instead of organising the whole commercialisation process it then just supported 800 family farmers with technical assistance (Grande Sertão, 2010). The following interview excerpt shows the position of Grande Sertão towards oilseed production and the biodiesel program. At the same time their general attitude about sustainable family farming that is based on diversity and in which oil crops are just one part of the mosaic becomes obvious.

> *"Like extractivism, we think that oilseeds are a good income alternative, an income supplement for family farming. But we do not think that oilseeds will save family agriculture, or that they will make family farmers rich, or that they will be the great output of family agriculture in Brazil, that is not at all, but we think it can make a*

> *contribution to income growth. And we think it is important to maintain the diversity of family farming because they have always lived like this: if the oilseeds are bad, we sell the corn, sell beans, if corn and beans are bad, we sell fruit, if this is bad, we sell wood. So it was always based on this diversity of market, of production. [...]"* (Interview with a representative of the Cooperative Grande Sertão, in Montes Claros - MG, on November 03, 2010, quoted from Ramos (2011, p. 90), own translation).

For the family farmers the most essential variables in the system are related to their everyday practical work. They emphasised the importance of having the possibility to borrow machinery when needed, because they cannot afford to buy it. Other important variables concern the ecological attributes of their region (i.e. soil quality, weather), but also commercialising, financing, and supporting aspects. Although half of the farmers grew castor beans before the PNPB started it is the first time for some families to gain a regular income, which they use to improve their quality of life. Both, technical assistance service and assured contracts, were judged as positive. Farmers' most urgent problems related to the weak soil quality, unpredictable weather conditions, insufficient machinery, delayed seed delivery, difficulties to get a loan from the bank, and a poor infrastructure.

4.3 Foci, problems, and strategies in 2012

During the first round of interviews two different types of family farmers could be identified: farmers working on their own and not associated with each other and farmers organised in a cooperative. The first group is located in the far north of Minas Gerais. Farmers in Matias Cardoso are representatives of this group. The second group was detected during the interviews with Petrobras and seemed to be an important contract partner for the company. In particular, this is the cooperative COOAPI in Chapada Gaúcha where farmers produce soy beans. To analyse them as part of the production chain, farmers and representatives of COOAPI were interviewed in the second round besides the stakeholders of the first round.

The following section gives an overview of the situation in 2012 and the evaluation of the PNPB by different stakeholders.

4.3.1 Evaluation of the PNPB in Matias Cardoso

In 2012, the collaboration in MC was still problematic. Petrobras still complained about the fact that it had to approach every farmer individually which meant incurring higher transaction costs. Moreover, Petrobras blamed the family farmers for breaking the contract by selling the harvest to other buyers.

One important change took place in the organisation of the technical assistance service. In Matias Cardoso it was no longer provided by EMATER but by Petrobras' own technicians. The reasons for this change were diverse. Amongst others, Petrobras and EMATER could not reach an agreement about the rate EMATER would get for each advised farmer. According to EMATER and some family farmers, the change resulted a decline in service quality. According to an engineer of EMATER, the area of castor beans in MC was reduced by 50 % between the crop years 2010/11 and 2011/12 (EMATER-MG, 2012).

From the family farmers point of view the situation worsened a lot since 2010. The following problems were mentioned during the interviews:

i) Family farmers and the technical assistance service referred to bad seed quality and late or no seed delivery by Petrobras other than agreed in the contracts. Instead of seeds the harvest from the previous year was given to the farmers which resulted in a mixture of different varieties on the fields.

ii) The seed variety preferred by Petrobras was more labour intense for the farmers than another type.

iii) The harvest was not collected or the collectors came later than stipulated by contract. Some farmers then sold their harvest to other buyers than Petrobras, because Petrobras did not buy or they could get a better price elsewhere. One of the middle men did not pay, as, allegedly, he went bankrupt.

iv) A lower price than the one stipulated by the contract was paid.

v) Bad weather conditions (40 days of drought during the rainy season) did not allow a successful cultivation of castor beans for those farmers who got the seeds too late.

vi) The contract breaches and an interrupted communication between Petrobras and the family farmers deteriorated the mutual trust.

Nevertheless, 85% of the interviewed farmers who still grow castor beans in MC said they were satisfied with the contract with Petrobras because a minimum price and the purchase are guaranteed; they got support like tractor hours, technical assistance and bags for the harvest. They believed their economic situation had been enhanced. 60% of the respondents said that they would continue to grow castor beans even if the PNPB ended, although they were already looking for alternatives, e.g. alternative buyers or alternative products.

4.3.2 Evaluation of the PNPB in Chapada Gaúcha

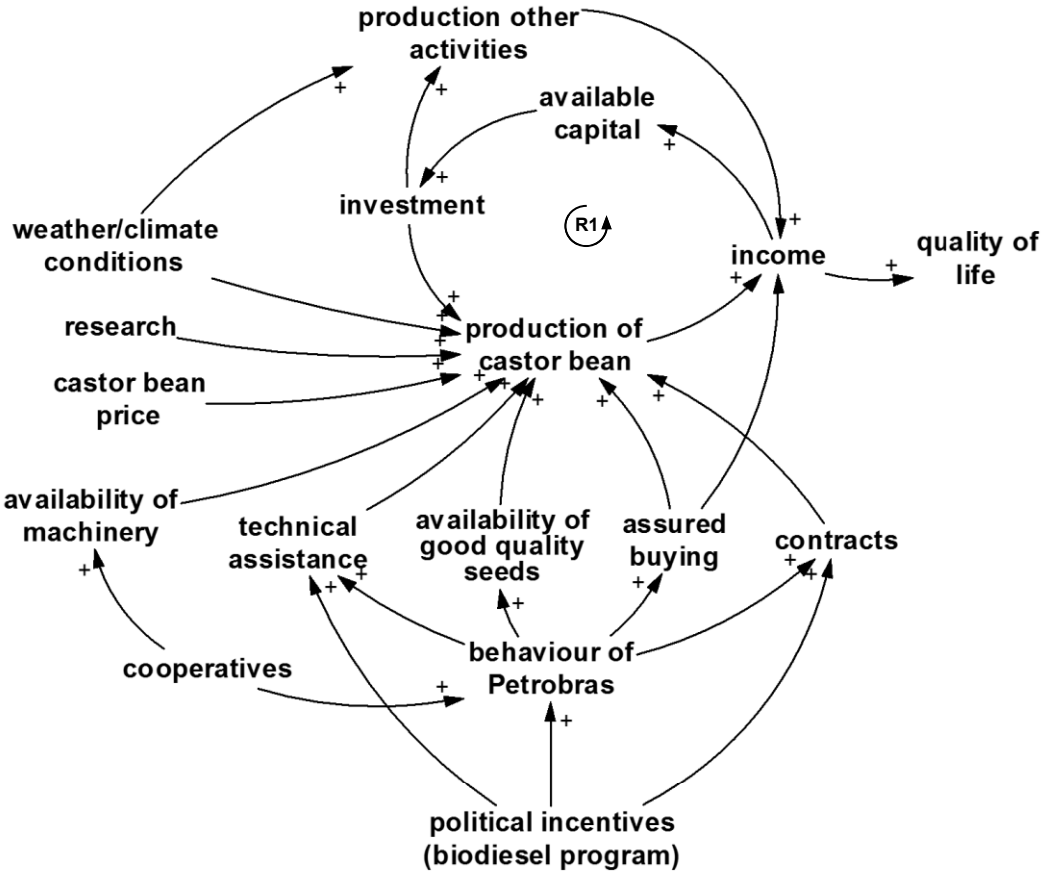
According to an interview with a representative of the biodiesel plant DRPB in May 2010, the cooperative COOAPI is the perfect contract partner for Petrobras (Petrobras, 2010). In 2011, the company bought around one thousand tons of castor beans in the north of Minas Gerais, whereas 18 thousand tons of soybeans were bought in the same region and period of time (Petrobras, 2012).

The cooperative COOAPI has a structured production chain and provides sufficient raw material for a reasonable price. In 2012, family farmers valued the PNPB as positive because the technical assistance had been enhanced. Initially, Petrobras promised to pay a bonus of 1 R$ per bag[13], which allowed the cooperative to hire a new employee and thus improve the technical assistance. Yet, besides this advantage, the farmers in CG did not see much difference with the PNPB. If the program ended everybody would continue to grow soybeans and just sell them to other buyers like before the PNPB started (e.g. Cargill, Bunge).

4.4 Causal Loop Diagram

As a synthesis of the different mind maps collected in 2010 a first simple Causal Loop Diagram of the castor bean production system was developed (Figure 38). The diagram shows the most important variables and their interrelations in the system. Each interrelation is marked according to its direction and effect. If an increase (or decrease) of one variable causes an increase (or decrease) of another variable this interrelation is marked with a '+' at the end of the arrow. If the effect is counteractive meaning that an increase of one variable causes a decrease of another variable (respectively a decrease causes an increase) the interrelation is marked with a '-'.

[13] Later on, Petrobras ceased to pay this bonus.



The Causal Loop Diagram lists the key variables of the agricultural system involving oil crop production under the biodiesel program.

Arrows depict the influence of one variable on another variable:
arrow with a '+' = reinforcing effect
arrow with a '-' = counteractive effect

R1 depicts a reinforcing feedback loop

Figure 38: Causal Loop Diagram of the agricultural system involving oil crop production under the biodiesel program

It is obvious that the production of castor beans is dependent on many other variables and a lot of these variables are depending on the behaviour of Petrobras. Just two forces are influencing Petrobras: cooperatives and political incentives.

On the other hand, there are variables like weather and climate conditions, research or the castor bean price that are not influenced by other variables and thus cannot be controlled within the system.

Another observation is that all interrelations are positive (marked with a '+'). Thus, the only loop in the system is self-reinforcing. As there is no balancing loop the system can react very fragile to disturbances which may run through the system and reinforce themselves.

4.5 Discussion

During the research process it has become apparent that each stakeholder has a distinct view on the system of biodiesel production. This reflects personal perspectives and differences between organisations. For stakeholders at local level other aspects matter than for those who operate nationwide. The following tables (Table 9 and Table 10) summarise stakeholders' perspectives and their most important problems faced in Matias Cardoso and Chapada Gaúcha in the years 2010 and 2012.

Table 9: Stakeholder's perspectives and most pressing problems with PNPB in Matias Cardoso

Petrobras	**Technical assistance**	**Family farmers**
• Focus on economic and organisational aspects • Relies on the technical assistance service	• Expert view, closer to the family farmers	• Focus on practicability in the field and day-to-day problems • Value technical assistance service and assured contracts
Problems in 2010		
• Logistics • Farmers' mechanisation degree	• Machines • Financing • Weather and soil conditions	• Machines • Financing • Weather and soil conditions • Infrastructure • Availability of seeds
Problems in 2012		

• Logistics
• Contract breaches by family farmers
  ○ Sale to other buyers
	• Contract conditions for technical assistance
	• Bad seed quality
	• Late seed delivery
		• Bad seed quality
		• Bad weather conditions
		• Communication with Petrobras
		• Contract breaches by Petrobras
		  ○ Late seed delivery
		  ○ Low price for castor beans
		  ○ Late or no collection of harvest

Table 10: Stakeholder's perspectives and most pressing problems with PNPB in Chapada Gaúcha

Petrobras	**Technical assistance**	**Family farmers**
• Focus on economic and organisational aspects	• Expert view • As part of the cooperative very close to the family farmers	• Focus on daily agriculture and markets • Value technical assistance service and higher prices for soy
Problems in 2012		
• No problems	• Weather conditions	• Weather conditions

Petrobras primarily looks at the economics and organisational part of the raw material production and use. It takes the perspective of a big industrial company that wants to have as little effort and costs with the purchase from family farmers.

Petrobras considers family farmers in MC as problem creators and hence as group in charge for finding solutions (mechanisation, building cooperatives). This attitude is confirmed by Hall et al. (2009), he cites a representative of a biodiesel refinery who stated that it is sometimes hard to deal with family farmers. The representative added that these farmers often have a lack of education, are not used to formal contracts and do not honour the advantages of a long term and stable business relationship. Petrobras sees the assured profit for the family farmers – which is according to Petrobras already assured by the contractual minimum prize – as their contribution to a working business relationship. In addition, they consider both parties to be responsible to build a better trust.

With the cooperative COOAPI in CG, Petrobras can benefit from a well-designed production chain and market integration of these farmers. The members of COOAPI represent the favourite type of family farmers from the industrial point of view – well organised in a cooperative, economically thinking and producing an efficient amount of raw material.

The representatives of the technical assistance service look at the topic from an expert point of view but as they advise the farmers and deal with their everyday problems they are closer to the farmer's point of view. As the role of technical advisors lies between farmers and Petrobras they are sometimes caught between two stools because they have to serve both sides. On the one hand, they are paid by Petrobras for the service they provide for the farmers, which means having obligations towards Petrobras. On the other hand, farmers expect good advice from the technical assistance. Thus, the advisors react to farmers' needs. Not least, they have their own interest, namely, to earn money. The more farmers they advise the more

money they can demand from Petrobras for the service. In the end, they have to bring all these three aspects together.

The interests of Petrobras and the technical assistance are not always congruent. This shows an interview with representatives of the cooperative Grande Sertão, where the production of castor beans does not comply entirely with the principles of the cooperative[14]. One major principle is the additional value creation through processing of raw material. As this is not wanted by Petrobras, the family farmers earn less than they would like to and the co-products from the process of oil pressing do not incur in the cooperative and cannot be used there. Moreover, the quality of the oil is high and Grande Sertão considers it too valuable for the production of biodiesel.

The family farmers' focus is more at the local farming practise. But the range of vision within this group differs as well. Some castor bean growing farmers have a quite narrow view on the system, which ends so to say at their farm gate, while others have a much wider understanding which includes possibilities to get further external support and to gain more profit by organising themselves and processing the castor beans collectively. This shows that most farmers understand their own agricultural system very well but have difficulties to see it in the whole system of biodiesel production. Their knowledge is very valuable, but concentrates on weather, soil and local conditions.

In MC farmers' decision to grow castor beans was determined by the expectation of a rising income and the assumption that castor beans are easily cultivated. Petrobras' promotion convinced farmers to participate in the PNPB. Many farmers in MC did not see any alternative to generate income than the cultivation of castor beans. They saw themselves as producers who make a contribution to the fulfilment of a biodiesel strategy for the whole country. In contrast to Petrobras they had fewer alternatives when choosing their contract partners because there were no other trustful buyers of castor beans in the region. Hence, contract breaches in form of not collected harvest by Petrobras were even harder for the farmers. This problem was also noticed by Hall et al. (2009) who cited an official of the Brazilian Agricultural Research Agency (EMBRAPA) who referred to family farmers that complained about companies who did not buy the harvest as assured in the contracts.

[14] The cooperative Grande Sertão functions as an association to develop and facilitate agro-ecological production methods and therefore gives technical assistance as support to commercialize the products. In the cooperative the cultivation of castor beans is just one line of production among many others. All the production lines have to be in compliance with the fundamental values of the cooperative which are:
• using the existing diversity of local resources,
• building a network of local famers,
• diversification of production,
• value creation in the cooperative through processing of fruits,
• production without chemical inputs,
• independence in closing contracts and selling their products.

The reason for difficulties with seed quality and provision in 2012 might have been that castor bean as a crop was still being enhanced through breeding. According to an engineer of EPAMIG (*Empresa de Pesquisa Agropecuária de Minas Gerais*) (EPAMIG, 2012) castor bean has not yet been adequately researched because the market is too small. Seed quality needs to be enhanced and the varieties have to be adapted to the different regions.

Although during the creation of the PNPB many different stakeholders were integrated into the process, the implementation can be characterised as a top down approach. Petrobras as a parastatal oil company was politically forced to implement the program and to work with family farmers. One might ask, if both parties wanted to work with each other. Certainly, the hierarchy between Petrobras and the family farmers was clearly visible. In MC this situation might have been described as a clash of two different production logics, which were not easy to bring together: family farming tradition versus agro-industrial development. These findings correspond with the experiences (Brune, 2011) made in a case study conducted in Piauí. In her opinion, the implementation of the biodiesel program failed because the culture and context of smallholders was neglected. Petrobras and the Agricultural Ministry believed that smallholders just need technological development to participate in the biodiesel value chain. This, however, is a reductionist view. Smallholders are more than just a smaller version of large scale agriculture (Brune, 2011). Beside profit maximization they are led by additional objectives, such as minimizing the risk of over-indebtedness, being less dependent on external inputs, diversification of production, environmental preservation, food security, orientation towards local markets, and the possibility to work with existing resources and traditional knowledge (cf. Mattei, 2015, p. 14). Moreover, many farmers are not used to formal contracts because they do not have much experience in negotiating and many of them cannot even read and write. Hence, they are not fully aware of the importance of a signature. This can result in contract breaches or distrust. Even if farmers value the contracts as security this could be deceptive in the future. Paradoxically, no biodiesel has been produced from the castor beans yet, because the price at the pharmaceutical market for castor oil is higher than the value for biodiesel. Thus, the continuation of castor bean production via the biodiesel program is questionable. Statements given by Petrobras in 2010 and 2012 indicate that they only work with family farmers to keep the *Social Fuel Seal* and the associated privileges. In fact, they prefer to work with soybean producing cooperatives or to purchase soybeans from even larger producers. This attitude might lead to a support of agribusinesses instead of family farming (cf. Laschefski & Barbosa, 2013).

Petrobras and the farmers deem each other responsible for a functioning biodiesel program. Both parties believe that the other party must change their behaviour for the system to work. Naturally, it is easier to blame the other party than to seek solutions and take responsibility.

Since no party had experience with each other and biodiesel was a new product for all, cooperation is challenging.

For Petrobras it would be a lot easier if the commodity in question was familiar to them (like soybeans or sunflower). This is the case in CG from where they obtain soybeans. Using soybeans supplied by COOAPI is a lot easier for Petrobras. It is simpler to negotiate solely with the administration of the cooperative than with every single farmer. On top of that, the purchase of raw material is simpler because it is organised by the cooperative. As the conferment of the *Social Fuel Seal* (which assures Petrobras tax reductions, advantageous loans, and access to the auctions) is bound to the purchase of raw material from family farmers Petrobras can fulfil this requirement either with the farmers in MC or easier with the farmers in CG (although in the cooperative 40 % of the members might have been no family farmers[15]). This might indicate why Petrobras needs the soybeans of COOAPI and where their future activities will concentrate. At the same time COOAPI seems to be less dependent on the contract with Petrobras because the cooperative has other options for selling their soybeans. This partnership seems to be on a level playing field.

Farmers' mind maps in CG towards the PNPB are not as problem oriented as in MC. Their view is a little wider than in MC. On the one hand, they focus on their local conditions, on the other hand, they think about markets and buyers beyond the PNPB. The reasons for growing soybeans for biodiesel production in CG lie mainly in the farming tradition brought from the south of Brazil. Farmers did not start soybean production for the PNPB but already had experience with growing soy for many years. Besides tradition, other criteria for the decision to participate in the PNPB were income and crop rotation.

The differing stakeholder opinions are very valuable to understand why problems arose in the production system as well as in the communication between actors.

The analysis of the Causal Loop Diagram shows the fragility of the biodiesel system. The absence of a balancing loop and the dependence on the behaviour of Petrobras are indicators for instability. This makes Petrobras a key player in the system and shows how much power the company has. Almost all variables that influence the production of castor beans are either dependent on the behaviour of Petrobras or not influenced by other variables within the system at all (weather/climate conditions, research, and castor bean price). Hence, these variables are not influenceable or controllable by the system itself and contribute to its fragility.

[15] A biodiesel processor is allowed to count raw material from a cooperative into the percentage of raw material from family farming if at least 60 % of the members of the cooperative are family farmers and hold the DAP (MDA 2012).

All key variables (behaviour of Petrobras, weather conditions, research, and castor bean price) have had an unfavourable development in 2012 from the farmers' point of view. The result was a virtual crash of the system where some farmers did not earn any money from castor beans at all.

5 ASSESSMENT OF LIVING CONDITIONS IN THE TWO CASE STUDY AREAS

Originally it was intended to collect data in a questionnaire survey to further develop the System Thinking model and to quantify its interrelations. As it became obvious that the farmers faced a lot of problems between 2010 and 2012[16] and that unexpected events are rather normality than a smoothly running system, the focus was shifted towards a better understanding of the agricultural systems, farmers living conditions, and opportunities. Additionally the statistical analysis of collected data did rather show any significant correlations between variables[17]. The reason is probably that the data basis was not large enough for the high heterogeneity within the sample. This heterogeneity cannot be displayed in a System Dynamics model as well.

The frequency of unexpected events made it necessary to explore points of intervention and alternative pathways. The development of a conceptual System Thinking model for a better understanding of the underlying structure seemed to be more productive than the quantification of a model that, due to frequently occurring and system overturning events, does not run normally.

As chapter 4 showed, the stakeholders have different mind maps and foci in their everyday work and their interrelations are formed by hierarchies and dependencies. The whole system of raw material and biodiesel production is characterised by fragility and reinforcing loops. These finding from a systemic point of view have their grounding in an inner structure of the system which has to be better understood first.

Thus, the following chapter gives a detailed picture of the regions MC and CG and the living conditions of family farmers who produce oil crops for the biodiesel plant in Montes Claros. The following questions are addressed in this chapter:

- What are the different preconditions in the two regions?
- Which effects has the biodiesel program in the two regions?

No survey existed that described the situation before the PNPB. Nevertheless, the situation in 2012 still displayed the different preconditions very well. In the survey agricultural data at farm

[16] Matias Cardoso was even harder affected by the problems than Chapada Gaúcha.
[17] Statistical analysis were executed with PASW Statistics 18. In the conducted regression analysis for hardly any variables a level of significance of 5 % could be reached. Only obvious correlations (e.g. between total area and the area cultivated with castor beans or between total income and income obtained from castor beans) could be affirmed. The reason is probably that the data basis was not large enough and that differences between farms caused a high variance for most variables.

level, history, geographical environment, quality of life, and the benefits and problems related to the biodiesel program were captured. Special emphasis was put on livelihood and social well-being.

5.1 Matias Cardoso: Settlement of family farmers with different backgrounds

5.1.1 Farm structure and land use

In MC, family farms are relatively small. The median farm size is 25 ha, of which 14.5 ha are cultivated. The rest is scrub land or temporarily not cultivated. Hardly any famer is leasing any land. The most important crop are castor beans, followed by pasture and maize (see Table 11). Common beans, other vegetables, and fruits cover a much smaller area but almost everybody owns a kitchen garden and an orchard and grows various vegetables and fruits for own needs. Chickens, beef cattle, cows, and pigs are kept partly for own needs and partly to sell meat, milk, and eggs on local markets. Horses and donkeys are kept as working animals. Cattle also serve another purpose: they are held for resale in case cash is needed in the short term.

Table 11: Farm size, areas, and heads of most important crops and animals in Matias Cardoso (MC)

	Median	Std. Deviation
Farm size (ha)	**25.0**	27.1
Cultivated area (ha)	**14.5**	10.4
Crops		
Castor beans (ha)	**5.5**	7.1
Pasture (ha)	**3.5**	8.5
Maize (ha)	**2.0**	5.2
Common beans (ha)	**0.5**	0.8
Water melon (ha)	**0.5**	0.6
Pumpkin (ha)	**0.5**	1.0

	Median	Std. Deviation
Animals		
Chickens (heads)	**20.0**	20.5
Cows/Cattle (heads)	**4.0**	9.5
Pigs (heads)	**3.0**	3.3
Horses (heads)	**1.0**	1.4
Donkeys (heads)	**0**	0.7

For their agricultural production farmers hardly use chemical fertilisers but some use organic fertilisers. On the other hand, everybody uses pesticides. For the production of castor beans 70 % of the interviewees used pesticides.

The cultivation of castor beans in MC mainly takes place on former cotton fields while food crops, except for some hectares of maize, were not replaced. The number of cattle has been more than halved (from a median of 10 in 2008 to 4 heads per family in 2012) since the introduction of the castor beans. 80 % of the family farmers who grow castor beans started this production in view of the opening of Petrobras' biodiesel factory *Darcy Ribeiro* in Montes Claros.

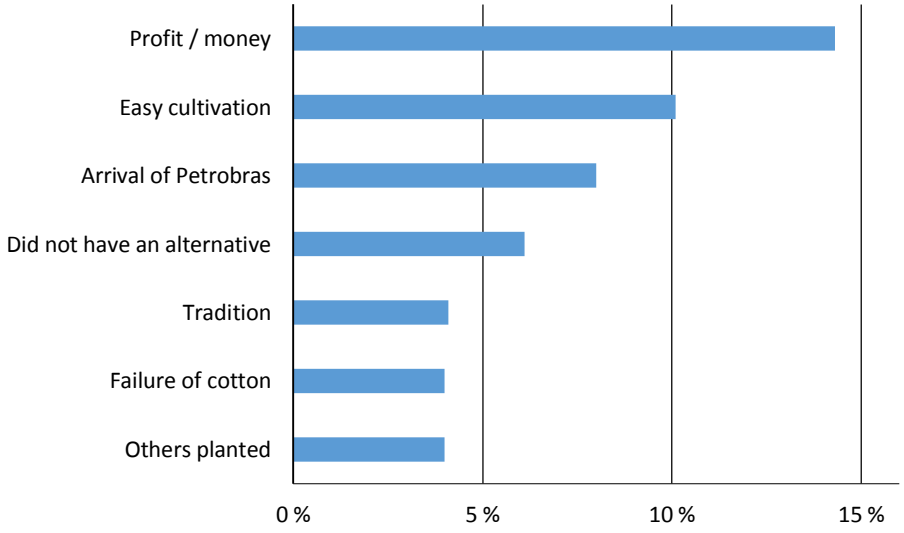


Figure 39: Reasons for the production of castor beans in MC

Asked for their reasons they mentioned expected profit and money in first place followed by the prospect of an easy cultivation of the crop (see Figure 39). The arrival of Petrobras was definitely one important factor. 6 % of the farmers said they did not have any alternative to the

cultivation of castor beans. This argument might be related to the mentioned reason of the failure of cotton production some years before. Tradition and the fact that neighbours planted castor beans were the reason for 4 % each.

How important the production of castor beans is for the farmers, is reflected by the following table (Table 12). It stands at first place regarding the financial income per ha. Moreover, the interviewees rated it as the crop that provides the greatest security. But it also requires the most work and has the highest production costs. The second place concerning income and security is held by cattle breeding followed by the production of maize (3.) and beans (4.). The most important crops and animals for own consumption are beans (1.), maize (2.), cattle (3.), and chicken (4.).

Table 12: Categorisation of agricultural activities concerning their benefits in MC

Agricultural activity that…	*1.*	*2.*	*3.*	*4.*
... has the highest financial income / ha	Castor bean	Cattle	Maize	Beans
... is most important for own consumption	Beans	Maize	Cattle	Chicken
… provides greatest security	Castor bean	Cattle	Maize	Beans
… requires most work	Castor bean	Maize	Cattle	Beans
… has the highest production cost / year	Castor bean	Maize	Cattle	Beans

Almost all interviewees grow fruits and vegetables for their own consumption. Thereby they reach the following self-supply rates:

- Common beans: 66 %
- Eggs: 52 %
- Pumpkin: 41 %
- Meat: 35 %
- Vegetables: 35 %

- Milk: 28 %
- Maize: 21 %

The staple food rice has to be bought by all interviewees.

5.1.2 Labour conditions

The mechanisation degree in MC is low and most work is done by hand or with the aid of animals. Asked about the labour intensity of agricultural activities the respondents in MC placed the cultivation of castor beans in first place closely followed by that of maize. Cattle and common beans are considerably less labour intensive. According to members of the technical assistance service the cultivation of castor beans in general is easy and requires no special skills or input. But the harvest, which is done by hand, can be complicated and labour intensive depending on the variety of the crop.

5.1.3 Income, debt, and wealth

The interviewed family farmers in MC have a median total income of 3 000 R$ per family member and year (see Figure 40). The total income includes subsidies, pensions, income from off-farm work, leasing, etc. The agricultural income adds up to just 1 500 R$ (median) per person and year on average. This means that just 50 % of the total monetary income is generated by agriculture in MC. 33 % of the total income is generated through the production of castor beans (which is more than three quarters of the agricultural income).

The debt level varies a lot between the farmers. The median debt level is 200 R$/person. Farmers took out a loan primarily to invest in their property or to buy animals (chickens, cows, pigs, and horses). Two interviewees in MC took up additional debt for the cultivation of castor beans. Loan creditor were usually the program Pronaf or the bank. Many farmers could either already pay back their loans or never took any, so that 34.6% of the respondents in MC do not have any debt. Besides these formal loans, farmers can also have informal loans which they might not have thought of when they were asked. For example landowners or informal intermediaries can provide services or inputs to the family farmers which have to be paid later (Howe & Goodman, 1992) similar to the common possibility to put something on the slate in shops. This invisible debt has to be kept in mind.

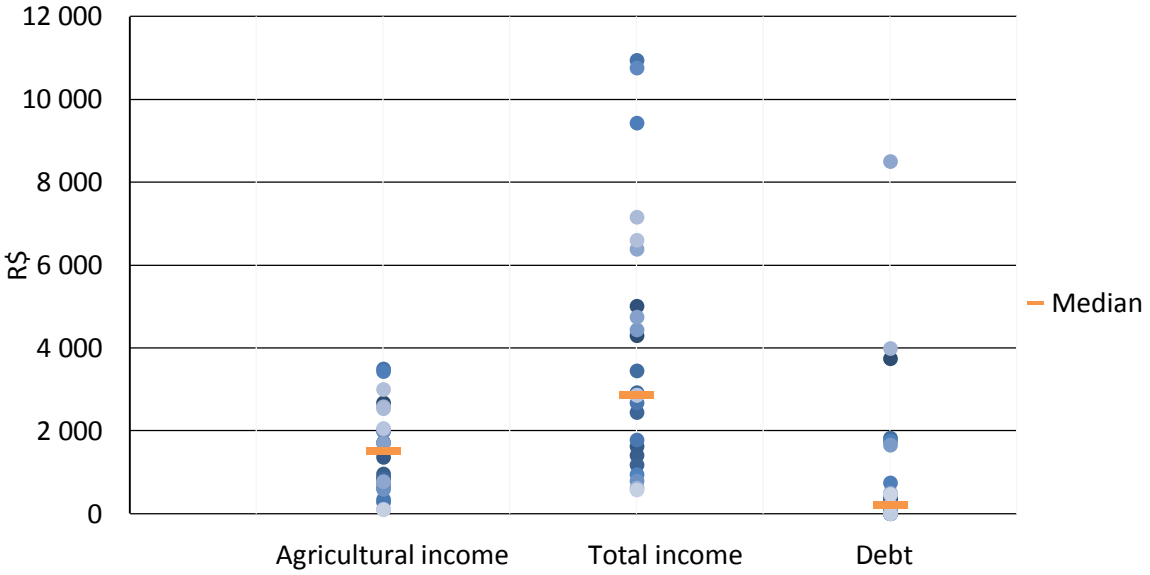


Figure 40: Income (R$/person/year) and debt (R$/person) of family farmers in MC, dots depict data of single farmers' households

The overall economic situation, which is measured by counting luxury goods in the household, corresponds to the presented income levels. Most of the interviewed farmers are in the lower economic classes C1, C2, and D (see Figure 41). Just 3 % of the farmers are found in the higher class B2.

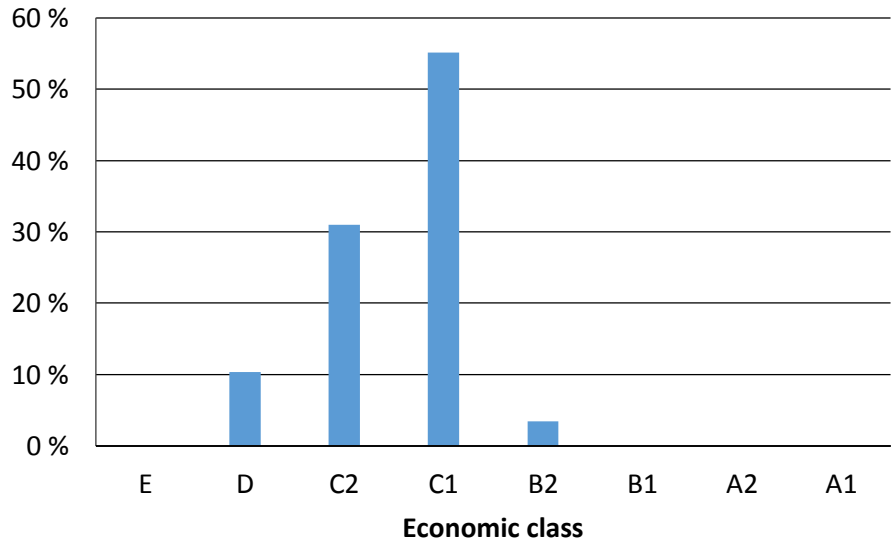


Figure 41: Economic situation of family farmers in MC

5.1.4 Life satisfaction

Contrary to the economic situation, life satisfaction in MC is on a high level. On a scale of 1-6 (where 1 marks the unhappiest and 6 the happiest) 90% located themselves in class 4-6. Even 59% ranked themselves equal or higher than 5. The highest class 6 is chosen by 41 % which is the largest group (see Figure 42). Many respondents stated that they like to live in the countryside and that they would rather stay than to move into a city because their personal valuation of quality of life is higher in the countryside than in the city. No interviewed farmer wanted to sell his farmland.

Although family farmers are not self-sustaining, two thirds of the respondents in MC claimed they have more food available compared to the time before they grew castor beans. They claimed this is possible with a higher income through castor bean production. This means they have a higher food security but no food sovereignty.

Figure 42: Life satisfaction of family farmers in MC

5.1.5 Production diversity and economic risk

The diversity of production which is measured by the diversity index of agricultural products (Figure 43) has to be divided into two indices in MC. The first one only includes sold products and is very low. Most family farmers have a diversification between 0 and 0.2 on a scale of 0 to 1. The reason is that they tend to concentrate primarily on the castor bean as only cash crop. The second diversity index, which also considers subsistence agriculture in MC, gives a different picture. The results show a shift to the right side of the diagram. Most family farmers are now in a class higher than 0.4.

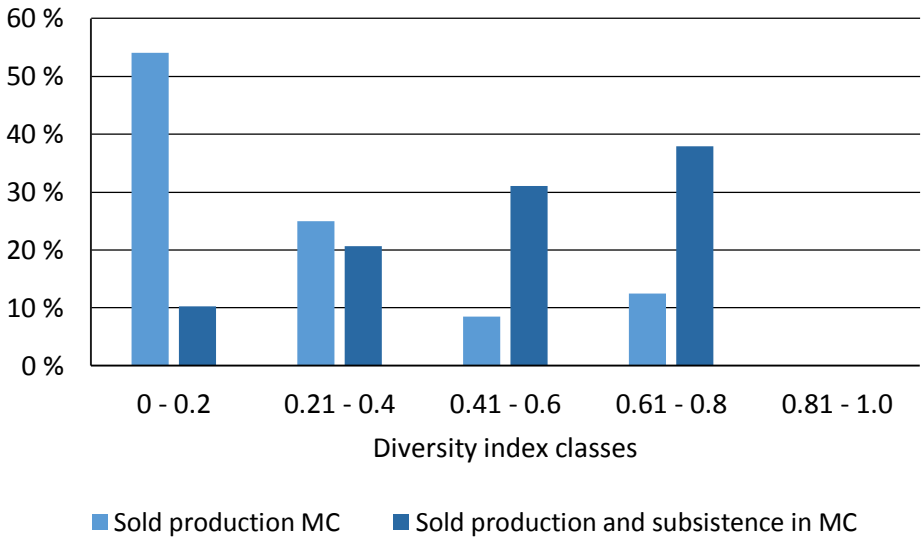


Figure 43: Diversity index of sold agricultural products and subsistence in MC

To estimate how much risk the interviewees would take economically, they were asked to choose between two sentences which one fits better for them. The sentences and the resulting ratio of farmers who agreed to the statements are shown in Figure 44.

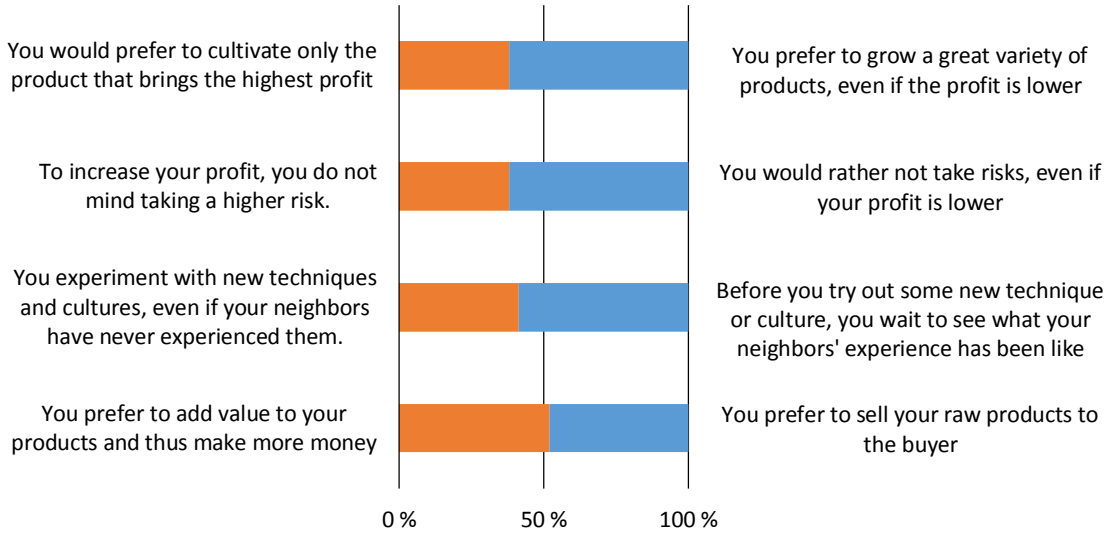


Figure 44: Farmers' readiness to assume a risk in MC

Around 60% of the interviewees prefer to grow a greater variety of products, do not want to take risks and wait for neighbours' experience before trying new techniques or cultures even though their profit is lower. This indicates their lower risk taking attitude. Concerning the degree of processing of their products 52% prefer to add value to their products to make more money.

5.1.6 Family and social network

Family spirit is of great importance in MC despite or because often family members have moved away. According to the interviews, in average, four individuals live together in one household. Over a third (38%) are under 20 years old. The next age group (20 to 39 years) comprises only 24% whereas the third group (40 to 59 years) is again bigger with 28% (see Figure 45). Young people between 20 and 39 years seem to leave the countryside and move to the cities. Typically, the family members work on the farm. The farmers tend to not employ permanent workers whereas seasonal workers are employed during the harvest.

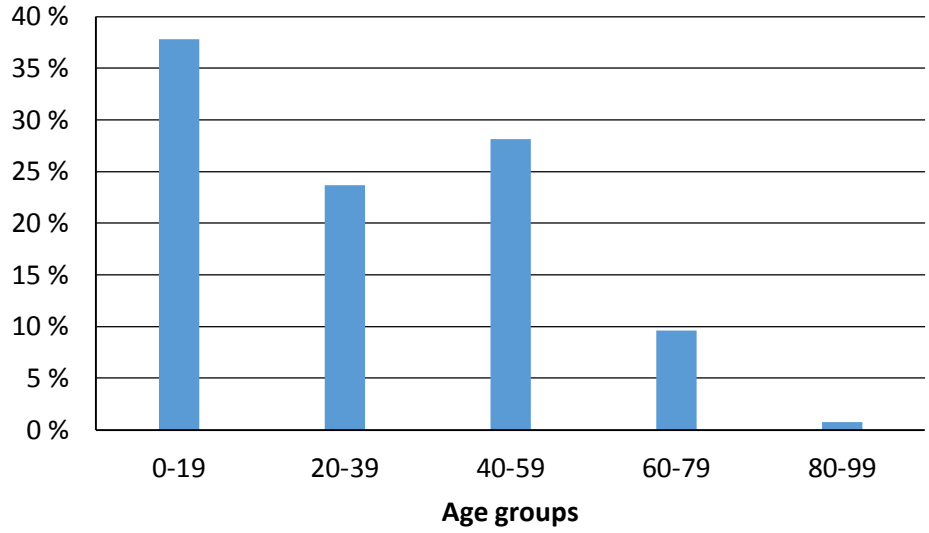


Figure 45: Age structure of family farmers in MC

But not only cohesion within the family is important. Famers also foster a strong contact with their neighbours. Figure 46 shows that 83% of the interviewees talk with their neighbours once a week. Agricultural meetings are attended less often: most farmers go once a month or once per semester.

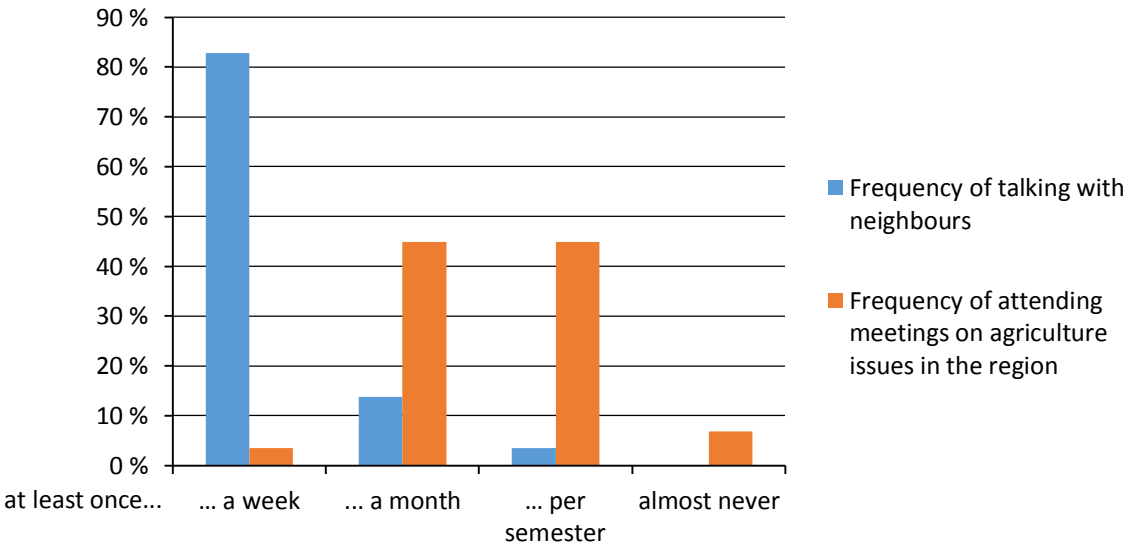


Figure 46: Frequency of farmers' social and professional interaction in MC

Besides talking and information exchange which is done by 79% of the interviewees, family farmers help each other in different manner (see Figure 47). Most important is help with manpower (83%) followed by use of equipment (66%) and marketing (55%). Purchase of inputs (34%) and equipment (14%) are less important.

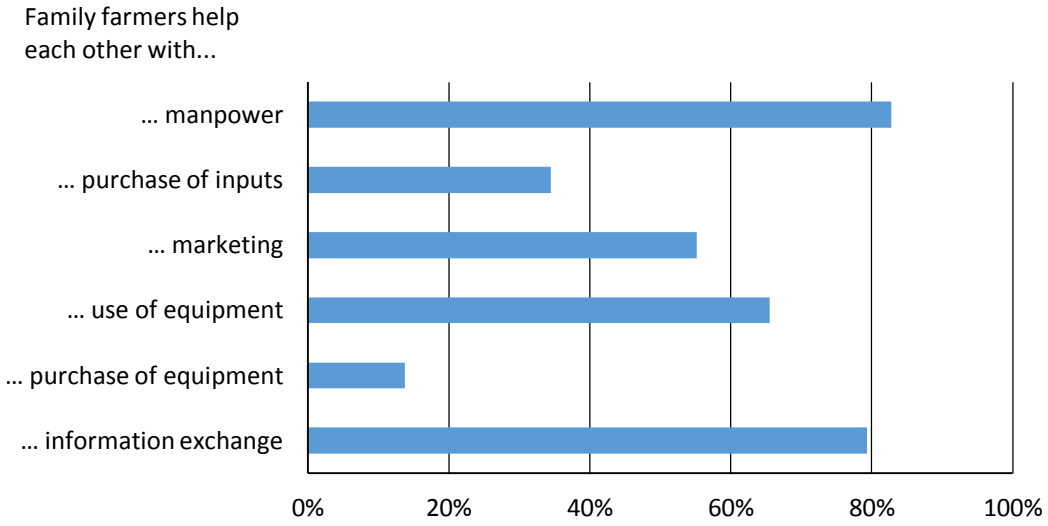


Figure 47: Forms of help between family farmers in MC

As well as informal bonds there exist some formal associations in MC which are more or less strong connected. Agricultural associations and man or woman associations in which 31% respectively 24% of the interviewees are members (see Figure 48) are loose aggregations of farmers living in the region. Also 31% are members in the labour union STR (*Sindicato dos Trabalhadores Rurais*).

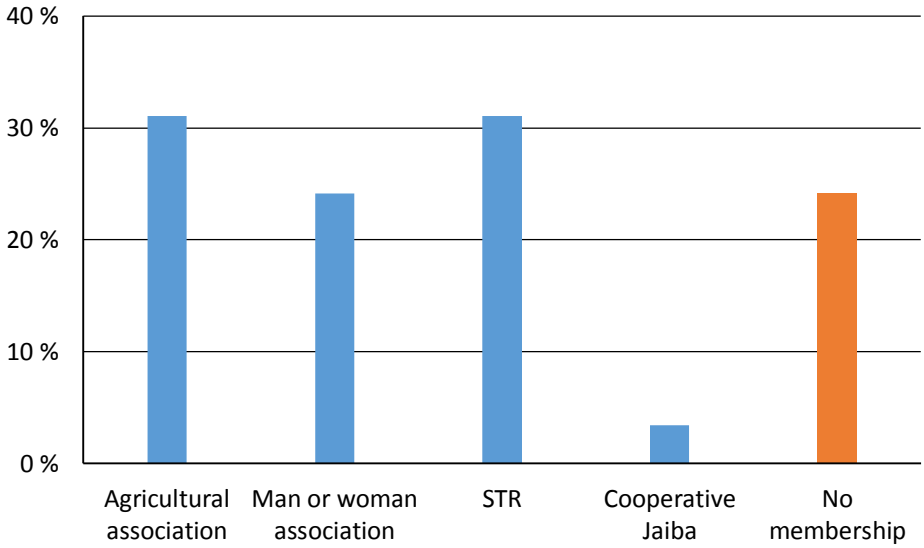


Figure 48: Memberships of family farmers

3% of the interviewees are already members of a cooperative in Jaíba which is located in the neighbouring municipality. But three thirds wish to participate in a cooperative. Most importantly they expect better conditions for commercialisation and the provision of inputs. Other advantages would be a better information flow, shared equipment, easy access to credits, and technical assistance.

5.1.7 Education

The education level in MC is very low. 39% of the interviewees are illiterate. Most people leave school after 5 years or less. Just 18% of the interviewees in MC attended school for 9 years or longer (Figure 49). The opportunity of obtaining a higher education is very limited in MC. Substantial distances have to be travelled which can be complicated considering the bad transport infrastructure and dirt roads or students have to move to another city.

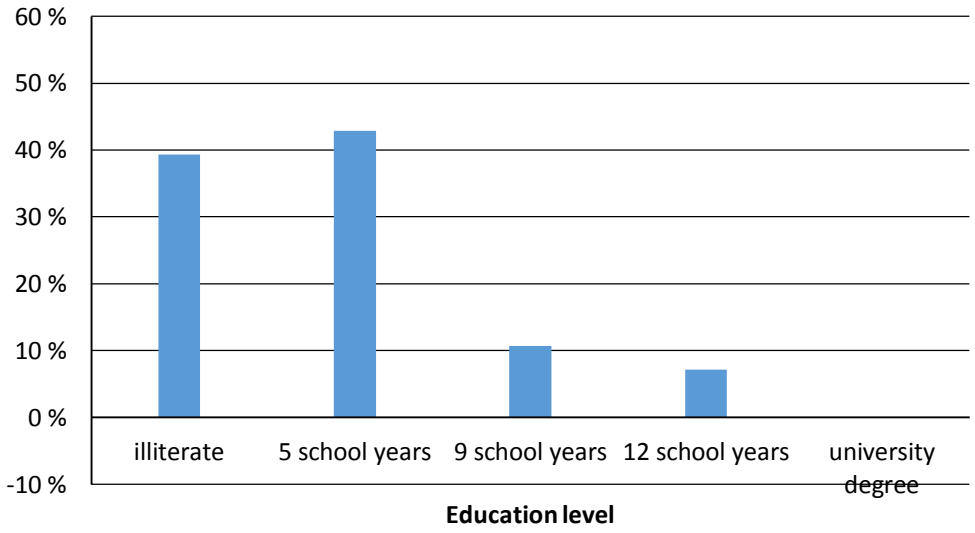


Figure 49: Education level in MC

5.1.8 Health

The health system consists of *postos de saúde* (health stations) in urban settlements. They provide a basic health service, specialised doctors are often not present. To get to a hospital people often have to travel a long distance. The closest hospital to MC is in Jaíba (62 km from MC), reachable from rural areas via dirt roads. This is one reason why people are not satisfied with the health system; just 34% in MC value the health system as good.

Rural life in MC is affected by some health problems connected to poor sanitary conditions. For example drinking water often contains a lot of salt which causes kidney problems. Another

problem, cited by the interviewees, is allergies to castor bean, which prevents sufferers growing this crop.

5.1.9 Recent problems and future prospects

During the last ten years the respondents in MC have been affected by several serious problems and state a number of consistent problems. Two thirds of them declared they had suffered crop loss through pests or drought. Abandoned state programs were a problem for 24% and 28% had problems with dying cattle. To handle these problems, farmers sold cattle, worked as hired labourers on larger farms or tried new agricultural activities. Besides agricultural challenges half the interviewees mentioned burdensome family problems like illness or death of family members.

The current most pressing problems are health (21%), future prospects (14%), finances (14%), family members moving away (14%), and drought (10%). Infrastructure and education are also sensitive topics. Nevertheless future hopes are positive. All respondents except one in each municipality believe that the economic situation will improve during the next ten years.

5.2 Chapada Gaúcha: Community of European descent settlers who formerly lived in the south of Brazil

5.2.1 Farm structure and land use

In CG, the median farm size is 250 ha of which 210 ha are cultivated (see Table 13). The remaining area is scrub land or protected area. On average farmers lease 170 ha.

The most important crop is grass seed closely followed by soybean. Both crops are cultivated alternately. Maize and common beans account for a very minor proportion and even pasture does not play a big role.

Besides crop production famers keep a number of animals. Partly they are kept for self-supply but most of it is sold to the market. As agriculture in CG is almost totally mechanised, farmers use own or rented tractors instead of horses or donkeys for the field work. Moreover they commonly use chemical fertilisers and pesticides.

Table 13: Farm size, areas, and heads of most important crops and animals in Chapada Gaúcha (CG)

	Median	Std. Deviation
Farm size (ha)	**250.0**	95.4
Cultivated area (ha)	**210.0**	130.4
Crops		
Grass seeds (ha)	**100.0**	96.0
Soybeans (ha)	**85.0**	77.4
Maize (ha)	**0**	8.7
Pasture (ha)	**0**	8.3
Common beans (ha)	**0**	1.4
Animals		
Chickens (heads)	**37.0**	46.8
Cows/Cattle (heads)	**10.0**	34.3
Pigs (heads)	**3.0**	20.1
Horses (heads)	**0**	2.2

The areal distribution of the crops corresponds with their importance for financial income and security. Grass seeds are in the first place, followed by soybeans (2.), maize (3.), and cattle (4.). The same order applies for required work and production costs (see Table 14). Grass seeds have a higher tolerance towards drought than soybeans, which is one reason for their greater profitability.

Table 14: Categorisation of agricultural activities concerning their benefits in CG

Agricultural activity that…	*1.*	*2.*	*3.*	*4.*
... has the highest financial income / ha	Grass seeds	Soybeans	Maize	Cattle
… provides greatest security	Grass seeds	Soybeans	Maize	Cattle
… requires most work	Grass seeds	Soybeans	Maize	Cattle
… has the highest production cost / year	Grass seeds	Soybeans	Maize	Cattle

Because farmers in CG grow mainly cash crops their self-supply rates with food crops is low. Only for meat they achieve a high rate. The following ratios of interviewed family farmers can supply themselves with the following goods:

- Meat: 92 %
- Eggs: 54 %
- Common beans: 31 %
- Manioc: 31 %
- Vegetables: 23 %
- Milk: 8 %
- Fruits: 8 %

Rice as staple food has to be bought by 100 %.

5.2.2 Labour conditions

In CG, all interviewed family farmers work with mechanised techniques. All but one possess their own tractor. That means most of the field work (sawing, cultivating, harvesting) is done using machinery. According to the farmers, growing grass seeds is more labour intensive than growing soybeans.

5.2.3 Income, debt, and wealth

The median total income of the interviewed family farmers in CG is 42 000 R$ per person. 70 % (29 000 R$ (median)) of this total income comes from agricultural activities, and the remaining portion originates from off-farm work and transfer payments (pension and social welfare programs) (see Figure 50). The main crop for agricultural income are grass seeds with which farmers earn almost three times as much as with soybeans (soybeans account for 24 % of the total income). The cooperative invests in technology and technical assistance and uses the internet for commercialisation purposes.

Except one respondent all farmers are indebted. The median debt level averages around 26 000 R$. The loans come predominantly from the bank or from Pronaf. Sometimes the cooperative, neighbours or parents give loans. They are mainly used to buy machines (tractor, other equipment), fertilizers or other inputs.

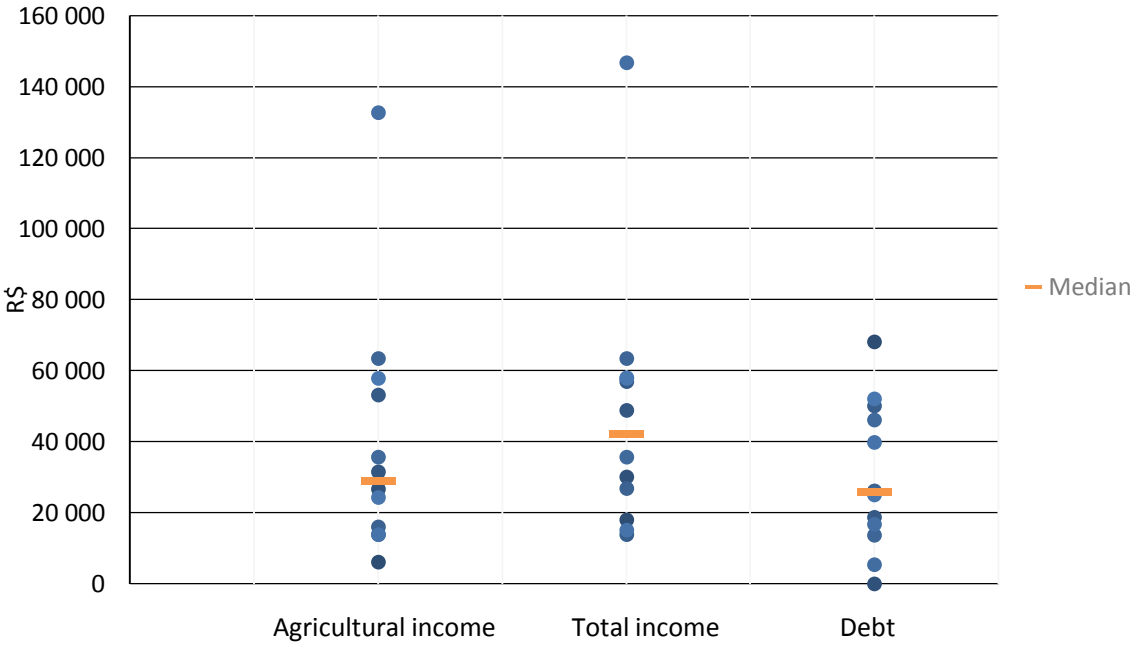


Figure 50: Income (R$/person/year) and debt (R$/person) of family farmers in CG, dots depict data of single farmers' households

The high income level is also reflected in the economic classes. As Figure 51 shows, over 75 % of family farmers in CG are in the higher A1-B2 economic classes – according to the classification used by the Brazilian Association of Research Companies (ABEP, 2012).

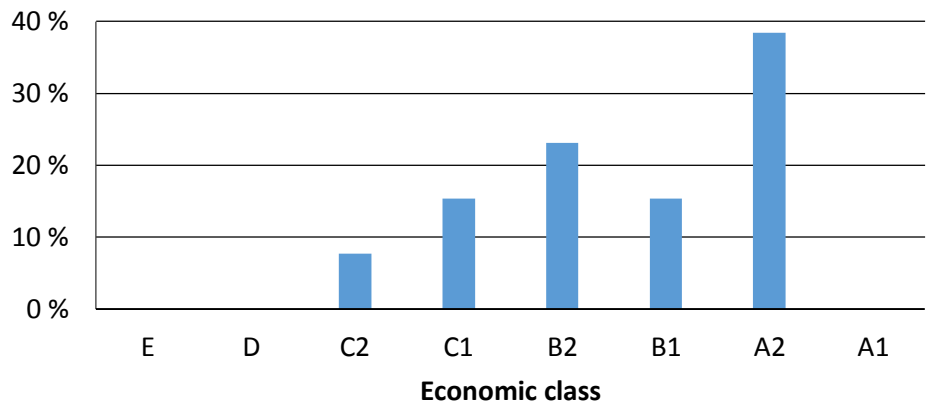


Figure 51: Economic situation of family farmers in CG

5.2.4 Life satisfaction

In line with the economic situation, life satisfaction also is high in CG. Over 90 % value their satisfaction equal or higher than 4 (on a scale from 1 to 6). 69 % are in the classes equal or higher than 5 and 31 % in the class 6 (Figure 52). Many respondents prefer living in the countryside over a city life.

Figure 52: Life satisfaction of family farmers in CG

5.2.5 Production diversity and economic risk

In CG, the production diversity is on a middle level (Figure 53). The respondents of the interviews are almost evenly distributed to the three segments between 0 and 0.6. Their income is generated from several sources – predominantly from producing grass seeds and soybeans. Because these two are very dominant, the diversity index does not exceed a value higher than 0.6.

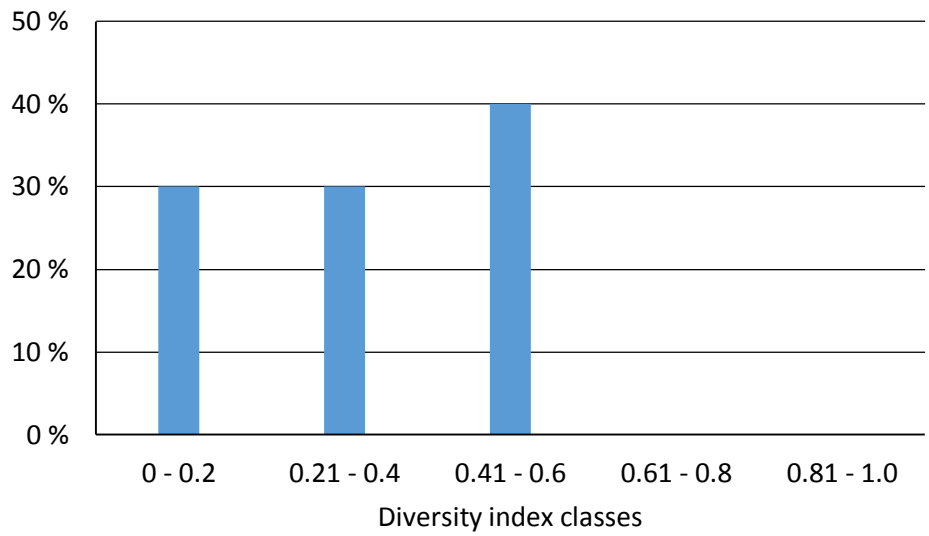


Figure 53: Diversity index of sold agricultural products in CG

The willingness to take a risk has to be analysed differentiated. Of all interviewees, 83 % rely on a great variety of products, rather than only the product with the highest profit (see Figure 54). 62 % even say they would not take a higher risk even if their profit is lower, whereas 54 % would experiment new techniques before their neighbours have experienced them. Regarding the processing degree, 77 % would prefer to add value to their products to make more money.

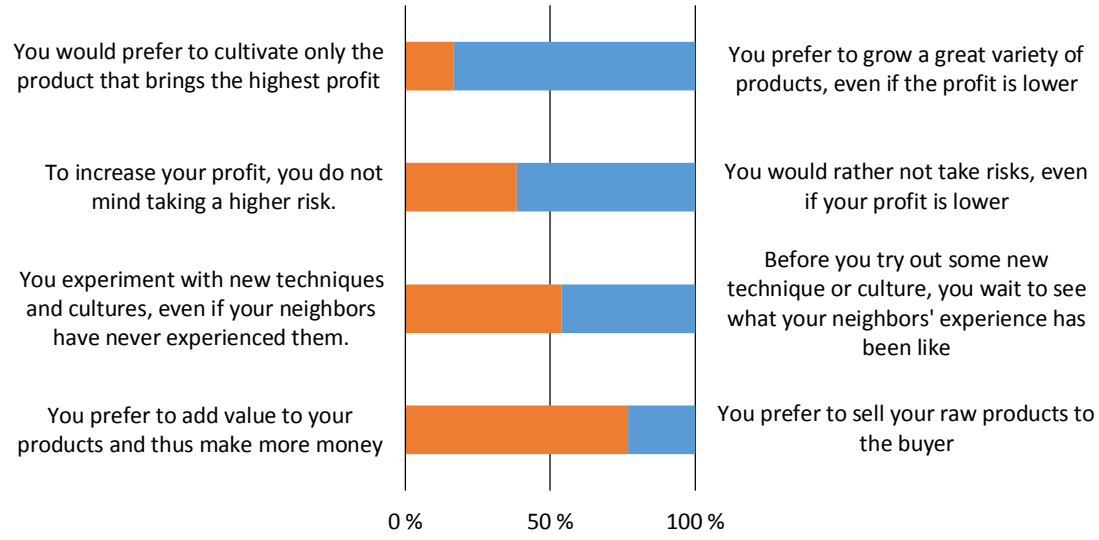


Figure 54: Farmers' readiness to assume a risk in CG

5.2.6 Family and social network

Living, working and keeping together as a family is very important in CG. One family living together in one household comprises four persons on average. The first three age groups (0-19 years, 20-39 years, 40-59 years) are with 27 %, 30 %, and 30 % almost equipollent (see

Figure 55). Family members work together on the farm and around a quarter of the farmers employs one or two permanent workers.

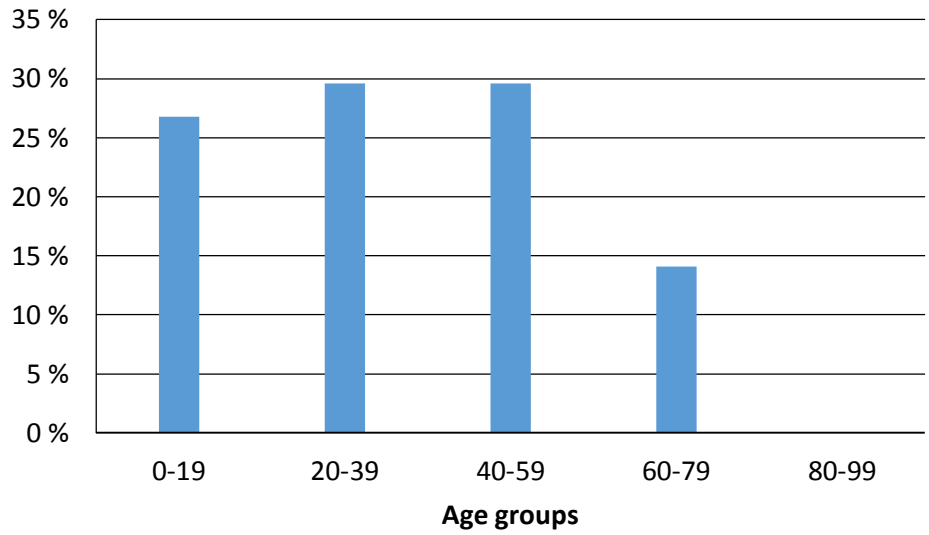


Figure 55: Age structure of family farmers in CG

Besides family ties, farmers also have a frequent communication with their neighbours. 92 % talk with their neighbours at least once a week (Figure 56). Meetings on agricultural issues are attended less often: 23 % attend them once a month, 62 % even once per semester.

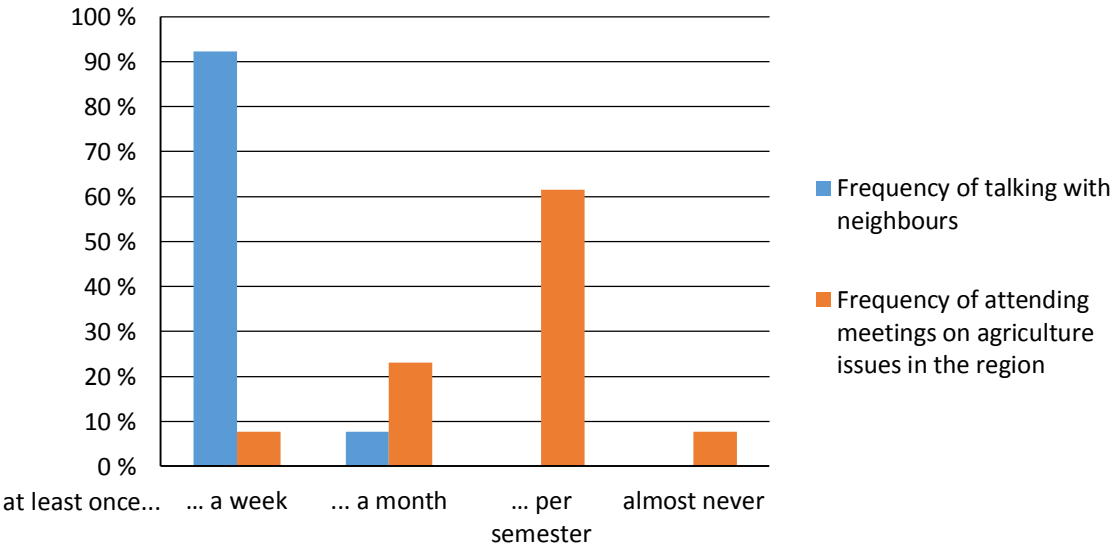


Figure 56: Frequency of farmers' social and professional interaction in CG

Helping each other is also very common in CG (see Figure 57). Respectively 92 % of the interviewees exchange information or equipment and 62 % help their neighbours with manpower. Collective purchase of equipment, inputs, and marketing are less important. These services are mainly done by the cooperative COOAPI.

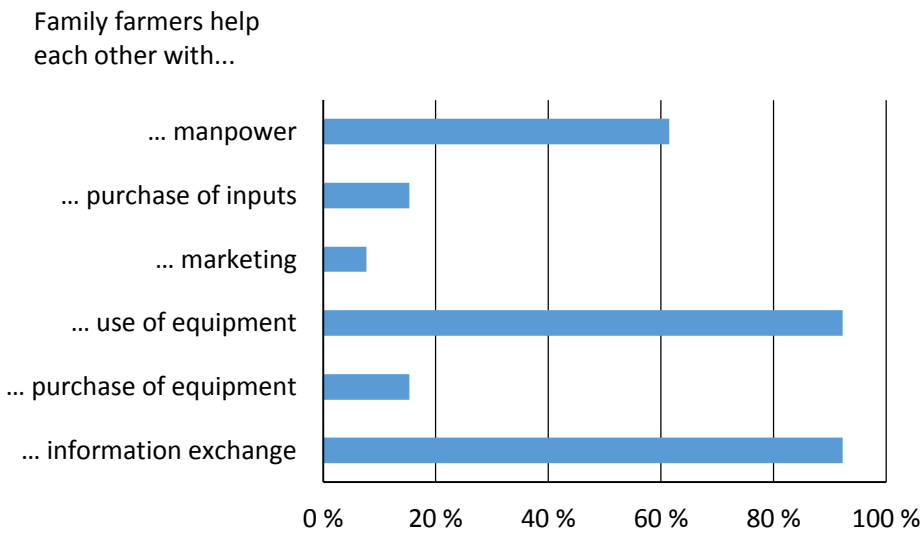


Figure 57: Forms of help between family farmers in CG

The interviewees see the benefits of COOAPI primarily in marketing and, secondly, in the purchase of inputs. Logistics, technical assistance, storage capacity, and solidarity were also mentioned.

5.2.7 Education

The education level in CG is on average. Just 8 % are illiterate, around three quarters of the interviewees attended school for 9 years or longer and even 23 % have a university degree (Figure 58). As there is no secondary school in CG, people have to travel long distances or attend a boarding school.

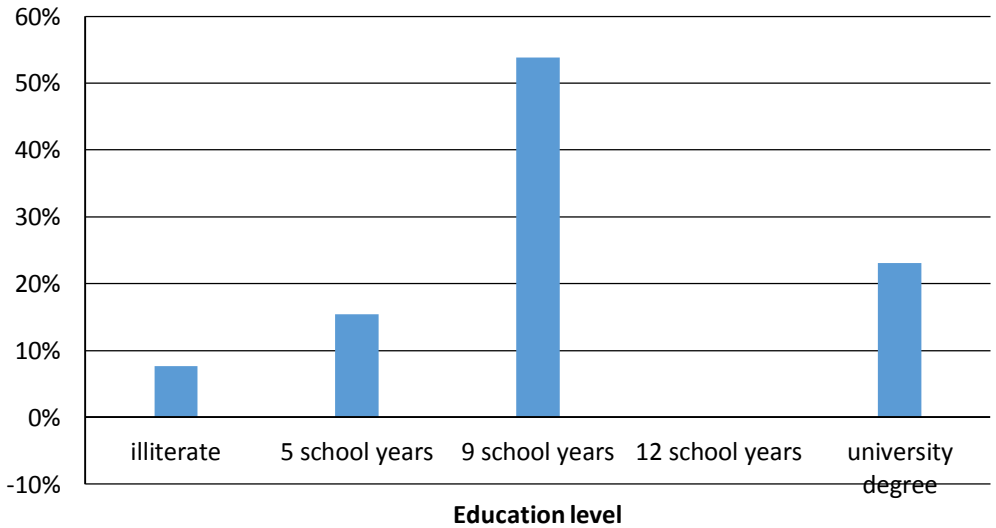


Figure 58: Education level in CG

5.2.8 Health

CG has a *posto de saúde* (health station) which provides basic health service, but has no specialised doctors. The next hospital is in São Francisco, 130 km away from CG. Most interviewees valued the health system as not sufficient. Just 38 % were satisfied and rated it as good. All in all, there are no typically regionally health problems.

5.2.9 Recent problems and future prospects

Family farmers stated a number of consistent problems which occurred during the last ten years. All interviewees complained about crop loss or drought which is the biggest problem. Another problem were decreasing market prices. Currently, farmers are most concerned about health (23 %) and finances (15 %). Infrastructure and education are also sensitive topics. Nevertheless, the expectations for the future are positive. Almost all respondents believe in an improvement of their economic situation during the next ten years.

5.3 Comparison of Matias Cardoso and Chapada Gaúcha

5.3.1 Effects of preconditions

The detailed exploration of living conditions revealed explicit differences between the two municipalities. They differ substantially in their agricultural structure (Table 15). The following section compares the preconditions in the two regions which are the result of different historical developments, different cultures, and geographical and infrastructural conditions.

Table 15: Preconditions in the two regions

	Matias Cardoso	**Chapada Gaúcha**
Farm structure and land use	• small farms (~25 ha) • few animals • no important cash crop besides castor beans • medium self-supply rates	• large farms (~250 ha) • many animals • grass seeds are most important crop • low self-supply rates
Labour conditions	• mostly hand and animal labour instead of machine use	• fully mechanised labour
Income, debt, wealth	• low income and capital resources • low availability of loans, low debt level	• high income and capital resources • high debt level
Life satisfaction	• middle to high	• middle to high

	Matias Cardoso	Chapada Gaúcha
Production diversity / economic risk	• high production diversity but almost no cash crops • low diversity of sold products • medium willingness to take a risk	• medium production diversity, several cash crops • medium willingness to take a risk
Family and social network	• strong family and neighbourhood ties • migration of young people • weak cooperative attitude	• strong family and neighbourhood ties • strong cooperative attitude
Education	• low education • high illiteracy	• higher education level • low illiteracy
Health	• bad health system	• slightly better health system

In MC family farmers have small lots, low incomes, few economic alternatives, a low degree of mechanisation and organisation, and a low level of education. Most farmers do not keep records and have a more intuitive way of working and making decisions. They grow subsistence crops and have added castor beans as the most important cash crop. However, the economic situation is not the only problematic topic. Young people seem to migrate, large-scale agriculture puts pressure on land, and drought is a serious problem. Moreover, health problems due to bad sanitary conditions occur more often.

The cooperative in CG is characterised by large farm areas, higher income and wealth, low to medium economic risks, a high education level and mechanisation grade, and well-structured arrangements. The organisational structure of the cooperative has grown over the last three decades and was initially brought from the south of Brazil. With a highly organised administration, farmers in CG are able to observe the market and to find the best prices and conditions. They can buy inputs in larger batches and profit from a lower price. Moreover, the geographical preconditions are favourable in CG (flat areas, easy to cultivate with machines) only drought is a problem. Gras seeds are the most important income source, soybeans are cultivated due to crop rotation requirements and tradition. The farmers are satisfied with their life, only the health system could be improved.

While in MC the median farm size of the oil crop is 25 ha, the farms in CG are ten times bigger. Comparing the cultivated area (total area minus protected or other uncultivated area) the difference is even greater. In MC most farmers do not lease any land while in CG the median area of leased land is 170 ha.

Income as an economic indicator varies substantially between the regions (Figure 59). While family farmers in MC have a very small total income per family member, in CG, they earn 15 times more on average. The difference in the agricultural income is even greater; it is 20 times

higher in CG. In line with the income situation, the debt level also varies a lot between the regions (Figure 59). Compared to their income, farmers in MC have lower levels of debt than their colleagues in CG.

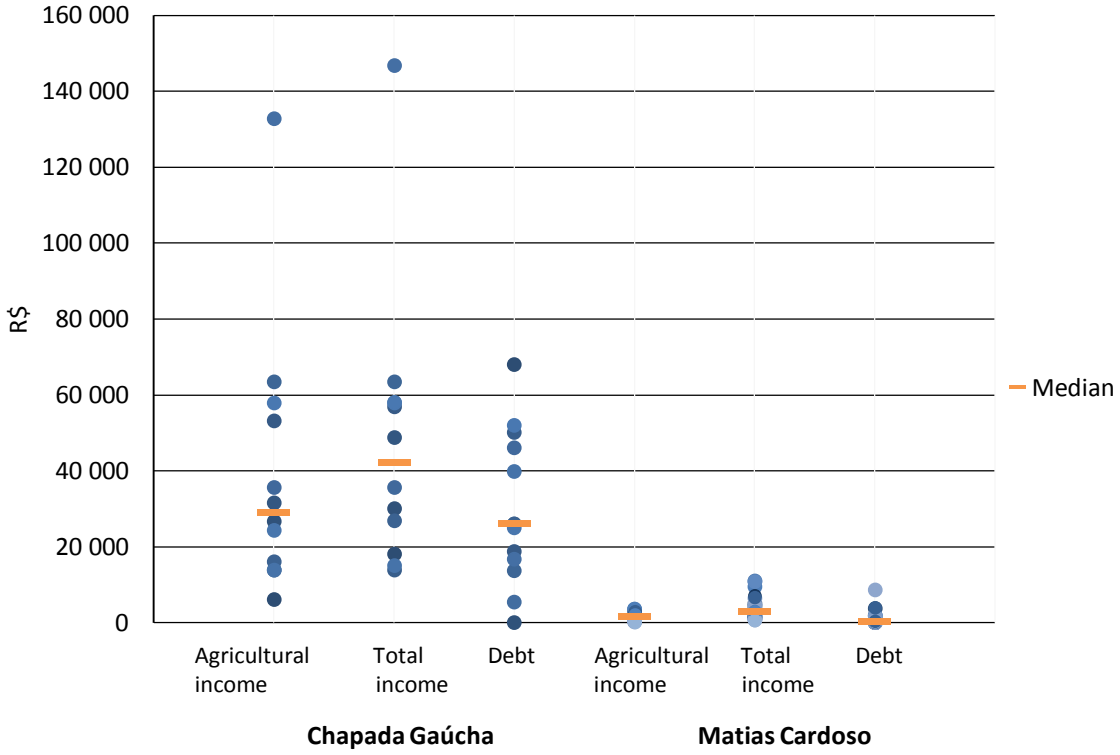


Figure 59: Income (R$/person/year) and debt (R$/person) of family farmers in MC and CG, dots depict data of single farmers' households

The different levels of income are also reflected in the economic classes in which the family farmers can be categorised (Figure 60). Family farmers in MC are in lower economic classes than their colleagues in CG, although there are overlaps.

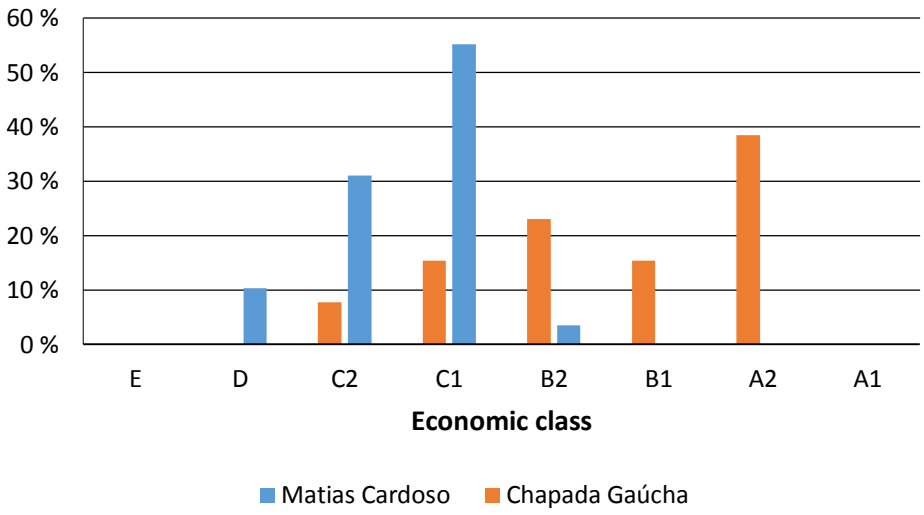


Figure 60: Economic situation of family farmers in MC and CG

As life satisfaction in both municipalities is on a high level (see Figure 61), there does not seem to be a direct link to the economic situation. The high levels are remarkable in light of several serious problems which occurred during the last ten years in both regions and which influenced the family and the agricultural business. Crop losses and drought affected both regions. Abandoned state programs are a problem in MC whereas in CG decreasing market prices are more of a problem. It shows that farmers in MC are more dependent on state programs than farmers in CG. Farmers in both regions are most concerned about health and finances. Infrastructure and education are also issues that need improvement in both regions.

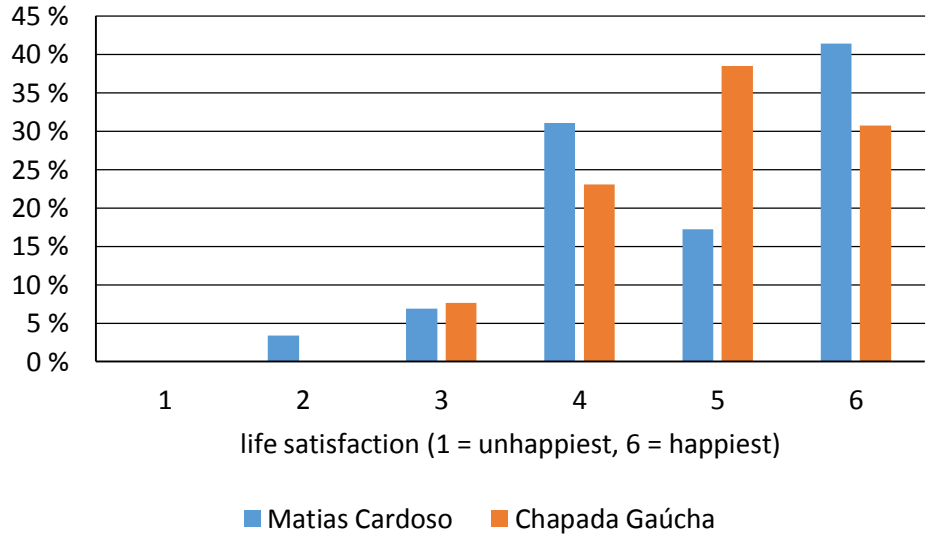


Figure 61: Life satisfaction of family farmers in MC and CG

Reasons for the relatively high level of satisfaction in MC, despite their problems and economic situation, could be that several factors influence happiness: income, family, satisfying work, social environment, health, personal freedom, and religion (Ruckriegel, 2006). The farmers might value the positive factors higher than the negative ones. Moreover, after the basic needs are fulfilled people tend to compare themselves to their direct neighbours and their living standard rather than to people with higher incomes living further away (Pietzcker, 2010). Another effect that might come into play is social desirability, which is according to Nederhof (1985 p. 264) “the tendency to say things which place the speaker in a favourable light”.

The diversity of production which is measured by the diversity index of agricultural products (see Figure 62) shows a very clear distinction between the regions. Family farmers in CG are on a higher level than the farmers in MC (only sold products are taken into account). The reason for the low level in MC is, that they tend to concentrate primarily on one cash crop (castor beans at the moment, pigs or cotton in former times). It makes them very dependent on this product. Compared to this, family farmers in CG get income from several sources instead of just one. The picture changes if self-consumed products are accounted for. This

means, farmers are less vulnerable if subsistence agriculture is also taken into consideration. Farmers in both regions show medium high levels concerning their willingness to take an economic risk.

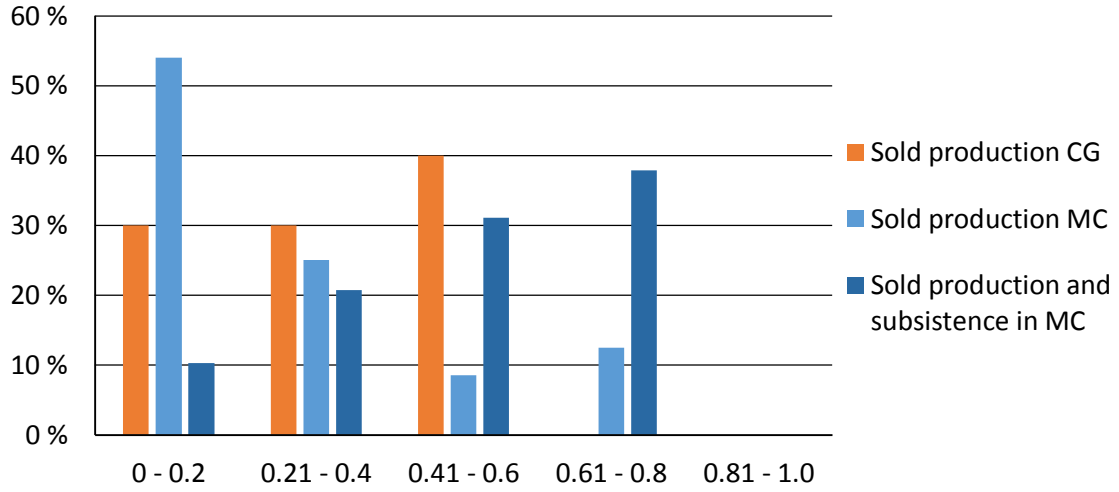


Figure 62: Diversity index of sold agricultural products (CG and MC) and subsistence (MC)

Family spirit is of great importance. Nonetheless, especially in MC many young people leave the region and move to the cities. However, not only family spirit is important. In both regions farmers have also strong ties with their neighbours and meet them almost every week. Most farmers also attend meetings about agricultural issues at least once per semester. The regions are differing in terms of cooperative attitude which is low in MC and very high in CG due to strong traditions.

The education levels are very different in MC and CG. In MC, 39% of the interviewees are illiterate, whereas in CG, only 8% are illiterate. The opportunity of obtaining a higher education is very limited in both municipalities.

In both regions the health system could be improved. Healthcare is slightly better in CG.

5.3.2 Effects of the biodiesel program on living conditions

The local preconditions need to be considered when evaluating the effectiveness of the PNPB in the two regions. The following section describes the effects of the PNPB that can already be observed in the regions (see Table 16).

Table 16: Effects of the PNPB in the two regions

	Matias Cardoso	Chapada Gaúcha
Farm structure and land use	• castor beans on around 40% of cultivated area • castor beans mainly on former cotton fields • number of cattle was halved	• soybeans on around 40% of cultivated area
Labour conditions	• easy cultivation of castor beans • harvest is labour intensive • no particular difference to other crops	• no difference, because soy was cultivated before
Income, debt, wealth	• castor beans are new and main income source • 33% of the total income comes from castor beans (more than three quarter of agricultural income) • very few additional debt for the cultivation of castor beans	• 24% of total income comes from soybeans • no real effects on the income height
Life satisfaction	• improvement during the last ten years for 66% of respondents • worsening during the last ten years for 21% of respondents • more food through better income	• improvement during the last ten years for all interviewees • PNPB has minor importance in this development
Production diversity / economic risk	• dependence through concentration on castor beans as only cash crop and only one contract partner (Petrobras)	• no significant effects
Family and social network	• more family members are involved in the production of oil crops than in CG • PNPB did not stop migration	• no significant effects
Education	• not measureable yet	• no significant effects
Health	• not measureable yet • only allergies are a new problem	• no significant effects

At first glance one could think the effects of the PNPB are mainly positive: family farmers' incomes in MC increased[18] or rather an additional income source was created, castor beans do not need pesticides and rarely investments, food production does not seem at risk, a higher income even enables the farmers to buy more food, labour conditions are acceptable, and

[18] However, it has to be kept in mind that family farmers often do not have an accounting system or a precise overview of their finances, inputs, and productivity. The quality of such data can therefore be very weak and the resulting indicators should be treated with caution.

people are mainly satisfied with their life and share positive hopes for the future. The positive evaluation of the respondents concerning the PNPB might though be influenced by social desirability: Farmers seem to share a lot of hopes concerning governmental programs and might be shy to criticise them.

On further consideration, however, such generalisation does not hold true in the long term: For the castor bean growing farmers in MC the PNPB provides indeed a short term opportunity to earn more income without high investments, assumed weather conditions are favourable, support, seeds and other inputs are delivered in good quality and in time, no contract breaches occur, and the market price remains high and stable. But many of these preconditions cannot be influenced by the farmers and they become dependent on outer conditions. The dependence becomes even more precarious in light of the low diversity index for sold products (which is caused by the PNPB and castor beans being the only cash crop and a reduction of the cattle herd size). Being able to buy more food increases food security but makes farmers dependent on a steady income. Food self-sufficiency which is one criterion for the *Social Fuel Seal* was not achieved (Laschefski, 2011). Having fewer cattle implies a diminishment of "saving balances" as in rural regions cattle is often regarded as a "bank book" which, in times of need, can be turned into cash (G. M. Souza, 2012). Less cattle bears the risk of not being able to get sufficient cash in the short term and to be more dependent on a regular income to be able to pay bills. Moreover, cattle provides a less risky although lower income than castor bean (EMATER-MG, 2012). It can be concluded, castor bean growing farmers are more vulnerable to crop failure, market conditions, the continuation of the PNPB, and the decisions of their contract partner Petrobras. The problems that occurred during the recent past already show that these concerns are real. Unusual weather conditions in the last years have further worsened the situation.

Family farmers in MC often have incomplete knowledge about their rights or market conditions – some cannot even read their contracts with Petrobras because they are illiterate – which leads to asymmetric power relations between the family famers and Petrobras. Family farmers in MC try to participate in the capitalistic market system but they do not have sufficient knowledge, skills, and abilities. Problems occur when they encounter strict market and contract rules. According to Laschefski (2011), Petrobras expects family farmers to prepare themselves to fit into the production logic of their company. However, they cannot meet on a level playing field because power and knowledge differences are too large. Laschefski (2011) speaks in terms of two 'worlds' with two different colliding perspectives: the market capitalist, large-scale production-oriented thinking of Petrobras on the one hand, and, on the other, the traditional, subsistence-oriented thinking of family farmers. Watanabe et al. (2012) also state that transaction risks and bargaining power are not symmetrically distributed among the contract partners. These preconditions make it much more difficult for farmers in MC to adapt to the

PNPB than it is for farmers in CG. Poulton et al. (2010) also emphasise limited education and power as crucial obstacles for a successful integration of family farmers into the market. Moreover, the low level of organisation and bad infrastructure make it difficult and expensive to approach every single farmer.

Although most respondents in MC claimed they would continue to cultivate castor beans even without the program[19], this would imply much higher risks, because they would lose the current support system of the PNPB (seeds, bags, transport, technical assistance, and assured minimum price). Hence, the income would likely decrease. At the same time the low diversity index will likely prevent this decrease from being balanced by other income sources in this region. As the farmers also grow insufficient subsistence crops they could face a food shortage.

The situation in CG is very different: The preconditions allow the family farmers to fit perfectly into the arrangements of the biodiesel program. The cooperative, as well as Petrobras, is well contented and both profit from the contract. The findings that the PNPB works well in CG are also shared by Watanabe et al. (2012) who state a reason for the success of the arrangement between COOAPI and Petrobras are low transaction costs on both sides and the strong culture of collective action. Schaffel et al. (2012) also stress the value of soybean family farmers for the biodiesel industry in Bahia and thereby underline the dependency of Petrobras on those farmers. However, the income effect for the soybean growing farmers under the PNPB in CG has been insignificant. If the program ends the better-off farmers in CG will not be confronted with big problems because they have other buyers for their soybeans. Also, in case of a total loss in one crop or product they will probably not suffer because their income is ten times higher compared to MC.

Although there is currently no empirical evidence Abramovay & Magalhães (2008) observed that the majority of the supply for biodiesel comes from center-west farms which are 50 to 100 hectares large. The authors fear “that only the more prosperous family farmers will manage to take advantage of the opportunities to participate in the markets opened up by biodiesel” similar to what happened in the beginning of PRONAF (Abramovay & Magalhães, 2008 p. 21).

In principle many aspects of the living conditions are unaffected by the biodiesel program: drought, unequal power relations, real integration into the market, energy service. Especially health concerns, education, and infrastructure are not enhanced through the program. As young people are still leaving the region of MC and move to the cities the PNPB does not seem

[19] The continuation of the PNPB in its recent form can be questioned because still less than half of the aimed number of family farmers participates in the program. Another reason which puts the program under pressure is the development of the soybean production of large scale farms which offer raw material of high quantities and low prices and are thus a concurrent to the family farms.

to be able to stop this. At the same time the PNPB creates some negative implications: dependence on the program, unfair contract conditions, and contract breaches.

Land prices are rising in both regions as stated by members of the agricultural advisory service in MC (EMATER-MG, 2012), the cooperative in CG (COOAPI, 2012), and the cooperative Grande Sertão (Grande Sertão, 2012). The prime reasons seem to be the expansion of large-scale farming (e.g. cattle breeding on pasture or eucalyptus plantations) and the construction of new infrastructure as for example roads (in CG) that enable better access. The production of raw material for biodiesel seems to be a minor reason because oil crops currently cover a comparatively small area.

5.3.3 Future scenarios

Three possible future scenarios were discussed during the future scenario workshop with representatives of family agriculture, technical assistance, and labour unions from the municipalities Matias Cardoso, Chapada Gaúcha, Varzelândia, Rio Pardo de Minas, and Taiobeiras. The first scenario described the situation *"The biodiesel program continues in the same form as it is at the moment"*, the second was named *"The biodiesel program ends",* and the third one represented *"The ideal scenario for the continuation of the biodiesel program"*.

The situations in the municipalities are very different. In addition to the already described differences between Matias Cardoso and Chapada Gaúcha family farmers from all regions shared their personal perception of the current situation concerning the biodiesel program.

In **Matias Cardoso** family farmers are disaffected with the biodiesel program. This disillusion is partly caused by the recent experiences (some farmers even experienced financial losses) and aggravated by the past experience with a former company who wanted to buy castor beans for biodiesel some years ago and in the end disappeared without buying anything (statement of a farmer during the workshop). Farmers' opinion about the company Petrobras is rather negative because they are unsatisfied with the quality of support (seeds, technical assistance). On the other hand, Petrobras is heavily recruiting family farmers in the region. The company wants the farmers to be better organised in cooperatives and promises support if the farmers do so. Thereupon the family farmers think about building a cooperative. At the moment they see no viable alternative to the cultivation of castor beans. The farmers believe they will overcome the current problems because they have already experienced several crises. They do not want to leave their farms but do not see many chances in agriculture for their children and grandchildren. Nevertheless, they want to keep the farm for their children in order to remember their origin.

Family farmers in **Chapada Gaúcha** see the biodiesel program as one option among others. They have several buyers for their soy beans. Although their profit raised slightly under the contract with Petrobras they do not rely on the program because Petrobras also thinks economically and only buys from COOAPI if they expect a profit. If the soy bean harvest is low Petrobras looks for more castor bean farmers and buys from them.

In **Varzelândia** many family farms are the result of the agrarian reform but smaller than in Matias Cardoso (see Table 6 at page 37). Farmers often work with intercropping systems. They also cultivated some castor beans intercropped with maize or beans as an additional income source. When Petrobras did not buy the harvest they dropped out of the program. As they did not have to pay for seeds or take on a loan they did not depend on the program and it was no loss for them. They criticized Petrobras for seed delivery problems, in some cases the seeds did not arrive in time and were not suitable for the region.

Family farmers in Varzelândia do not like to take a risk and always work with their own resources. Crop diversity and using cattle farming as “saving accounts” are the basic pillars of their system. Founding cooperatives is seen as difficult as farmers are work and live very independently. Technical assistance and continuing education are seen as very important and are taken advantage of by the farmers. Recently, there was less out-migration.

Preconditions and experiences in **Taiobeiras** and the neighbouring municipality **Rio Pardo de Minas** are comparable to those in Varzelândia. Family farmers gave the cultivation of castor beans a try on their small lots but failed. So they dropped this crop again. They also complained about the poor quality of technical assistance. As they previously have had negative experiences with credits for other projects and partly still need to pay back money for loans, they decided not to take new loans for the cultivation of castor beans. Their main income sources are rapadura (candy of the juice of the sugar cane), cassava flour (which they commercialise in a cooperative), and milk production. Some produce cheese or a special type of biscuits. The region suffers under the cultivation of eucalyptus by big companies and the resulting water shortage.

5.3.3.1 Matias Cardoso

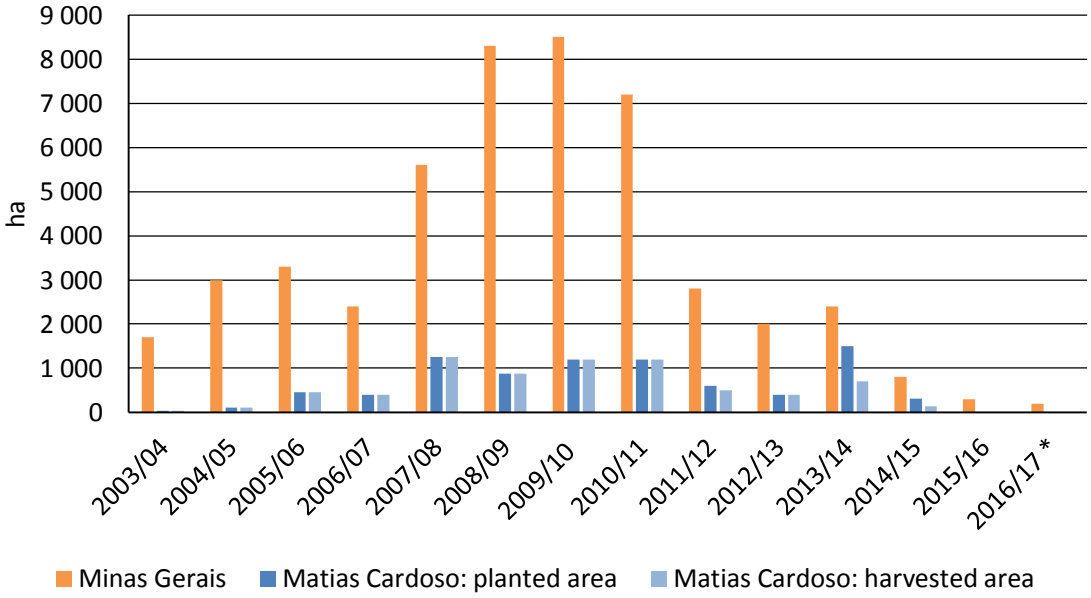
Under the first scenario (*The biodiesel program continues in the same form as it is at the moment*) family farmers in Matias Cardoso would continue with the cultivation of castor beans but also force a continued diversification of production (maize, beans, chicken, pork, cattle). Castor beans are seen as a good income source. Their second important income source is cattle. In addition, they want to drill wells to irrigate their fields. Becoming part of the cassava

cooperative in Rio Pardo de Minas is seen as another alternative and farmers would raise the production.

Assuming *the biodiesel program ended* some farmers would leave the region, others would stay. Children would rather move to the cities. The cultivation of castor beans would be more difficult without guaranteed buyers, the prices could fall, and new buyers would have to be found. Alternatives would be to add value through the further processing of castor beans, the cultivation of maize and beans, and irrigation cultivation of vegetables.

The *ideal scenario* for farmers would be if Petrobras was a reliable partner who complies with the contracts. Farmers who already left the region would come back. Farmers could enlarge their cultivated area and grow more castor beans. The additional income would be invested in the property and for consumption.

A look at the planted area in the years after the workshop shows that the recruiting process of Petrobras had some success in 2013/14 (see Figure 63). Maybe because only half of the planted area was harvested in that year the area of castor beans declined during the following years. Only 200 ha were estimated to be planted with castor beans in Minas Gerais in 2016/2017.



Source: IBGE (2017) and Conab (2017) *estimated area from January 2017

Figure 63: Planted area of castor beans in Minas Gerais and planted and harvested area of castor beans in Matias Cardoso

5.3.3.2 Chapada Gaúcha

Family farmers in Chapada Gaúcha would in all scenarios continue with the cultivation of soy beans because it is their tradition and they need them for crop rotation. If the biodiesel program ended they would sell their harvest to other buyers like in the past. Their ideal scenario would be a continuation of the biodiesel program and a good consensus between the cooperative and Petrobras concerning the supply contract and its conditions.

5.3.3.3 Varzelândia

If the conditions of the biodiesel program with all its problems stayed the same (scenario 1) family farmers in Varzelândia would feel virtually excluded. They do not want to become dependent on Petrobras or to be pushed towards monocultures as they want to keep their diversity.

If the biodiesel program ended (scenario 2) this would not have a big impact on them because they did not rely on Petrobras. They would continue to grow other crops than castor beans as they were only an additional source of income.

The ideal scenario (scenario 3) would be that family farmers organise themselves in cooperatives and that the government provides incentives for the production of castor beans and makes sure that seeds are produced that are adjusted to the regional conditions. The breeding *Guarani* would be preferred and should be available at sawing time.

5.3.3.4 Taiobeiras and Rio Pardo de Minas

In Taiobeiras and Rio Pardo de Minas castor beans are no longer cultivated. Family farmers from these two municipalities partly work with agro-ecological methods. Concerning the three scenarios they would act very similarly to the family farmers in Varzelândia.

5.3.3.5 Interim conclusion

Through the biodiesel program many family farmers were mobilised and some profited whereas others experienced no difference or even losses. These differences are based on factors like region, local conditions, farm size, and personal preconditions.

The statements during the workshop showed that family farmers rely on the principal of diversity and self-sufficiency but are also looking for one or more cash crops to be sold at the market without a lot of investment in advance. This do not have to be castor beans. Important

for them is diversity in farming, a reliable contract partner, technical assistance, and support by a governmental program.

The almost complete abandonment of castor beans in 2016/2017 in Minas Gerais leads to the conclusion that it was not profitable or that the collaboration between family farmers and Petrobras remained problematic.

6 SWOT ANALYSIS OF SYSTEM THINKING MODEL

6.1 System Thinking model

The insights gathered during the survey and the workshops enabled the enhancement of the first Causal Loop Diagram (Figure 38) and the development of detailed System Thinking models of the agricultural systems which integrate the production of raw material for biodiesel production under the PNPB (Figure 64). Despite the production of soybeans and castor beans the models contain the same variables for MC and CG. The models consist of system relevant variables and their polarized interrelations. Most interrelations are reinforcing (marked with a '+' at the end of the arrow, indicating that an increase of one variable causes an increase of the effected variable). Only bureaucracy, the behaviour of Petrobras and contract breaches have a counteractive effect (marked with a '-', which means that an increase or bettering in one variable results in a decrease or worsening of the effected variable). Three reinforcing feedback loops are central in the diagram (thicker arrows). They are marked with the letter 'R' (for reinforcing) and the numbers 1-3. The first loop R1 contains the four variables *available capital*, *investment in soy-/castor bean*, *production of soy-/castor bean,* and *income*. The more capital is available, the more can be invested in soy-/castor bean, and the higher is the production and thus the income. Of course this is a simplification because other variables also influence the process. For the analysis of the systems behaviour this reduction is necessary. Because of the reinforcement character of this loop either a positive impulse as well as a negative impulse will be intensified during the loop and can easily bring the system out of balance. The second reinforcing loop contains the variables *available capital*, *investment in other activities*, *production of livestock* and *income*. The third reinforcing loop consists of the variables *available capital*, *investment in other activities*, *production of other crops,* and *income*. Similar to the first loop, with more available capital, famers can invest more in other activities and thus produce more livestock or other crops and earn more income. On the other hand, a decrease in production can result in lower income, lower available capital, and lower investment in the next production period. The reinforcing character will accumulate positive as well as negative disturbances. Variables that can directly influence the described loops are: *credits*, *soil conditions*, *weather/climate conditions*, *infrastructure*, *availability of machinery*, *technical assistance,* and *social benefits* (transfer payments). These variables were always inherent of the agricultural system. Newly added by the biodiesel program are the following influencing variables: a*vailability of good quality seeds*, *assured buying*, *contract breaches,* and *information access*. As it became obvious during the research these variables all showed negative tendencies in the last years and are thus a threat for the systems behaviour. The *behaviour of Petrobras* has in turn a direct influence on the last mentioned variables. A

counterpart on this can be *cooperatives* which can, on the one hand, enhance the *availability of machinery* and, on the other hand, are powerful enough to put pressure on Petrobras. The variable *quality of life* is dependent on *income* as an economic relation and *on the production of other crops* and *livestock* because these products can be used for self-consumption.

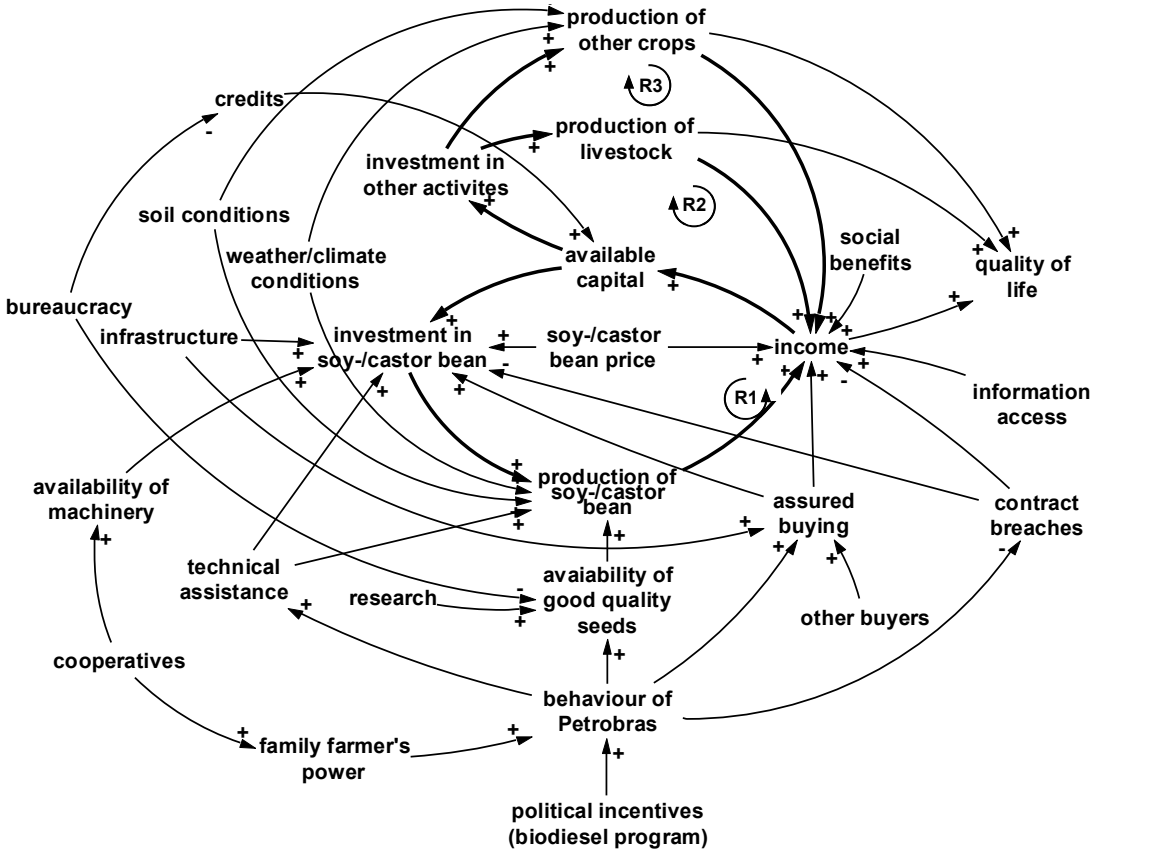


Figure 64: System Thinking model for MC and CG

6.2 SWOT analysis

The aim of the SWOT analysis was to evaluate the resilience of the agricultural systems that involve oil crop production under the PNPB. The knowledge gained by the explorative research enabled the evaluation of the variables of the System Thinking model. Strengths, weaknesses, opportunities, and threats of the system were identified based on the recent history and actual development in MC and CG. Additionally to the structural insights this evaluation provides further explanations for the systems behaviour. Figure 65 and Figure 67 show the SWOT

analysis for the System Thinking models of the two in the PNPB participating agricultural systems in MC and CG. Each variable is coloured according to its evaluation using the SWOT framework (cf. Figure 35). The meaning of the colours is as follows:

- light blue = strengths,
- orange = weaknesses,
- dark blue = opportunities,
- red = threats.

The diagrams also indicate which variables are strongly influenced by the PNPB. These variables are included in a black box. Variables in a grey box are partly influenced by the PNPB.

Figure 66 and Figure 68 display the respective SWOT matrices of the two systems where the variables are grouped into the four SWOT categories.

6.2.1 Matias Cardoso

The system in MC is characterised by considerably more threats (red) and weaknesses (orange) than strengths (light blue) and opportunities (dark blue) (Figure 65).

In MC five variables belong directly to the PNPB complex: *political incentives (biodiesel program)*, *behaviour of Petrobras*, *availability of good quality seeds*, *assured buying,* and *contract breaches*. Another three variables belong partly to this complex: *Technical assistance*, *castor bean price*, and *information access*.

Inner strengths of the agricultural system in Matias Cardoso are the *investments in castor bean* and *other activities.* Due to an evolved high production diversity (cf. diversity index in chapter 5.1.5) *other activities* comprise various activities (livestock, field corps like maize, common beans, vegetables, and fruits). The production of cattle, which is not only a source of income but also a kind of "savings account", is valued as positive. The production of other crops and livestock is not extremely high but provides the farmers with a continuous food supply or an income source respectively. The result is a small but regular income. Including the income from castor beans and social benefits, such as pensions or *bolsa família*, the interviewed farmers have stated that they enjoy a satisfying quality of life. However, the income from castor beans must be regarded as insecure due to several uncertainties.

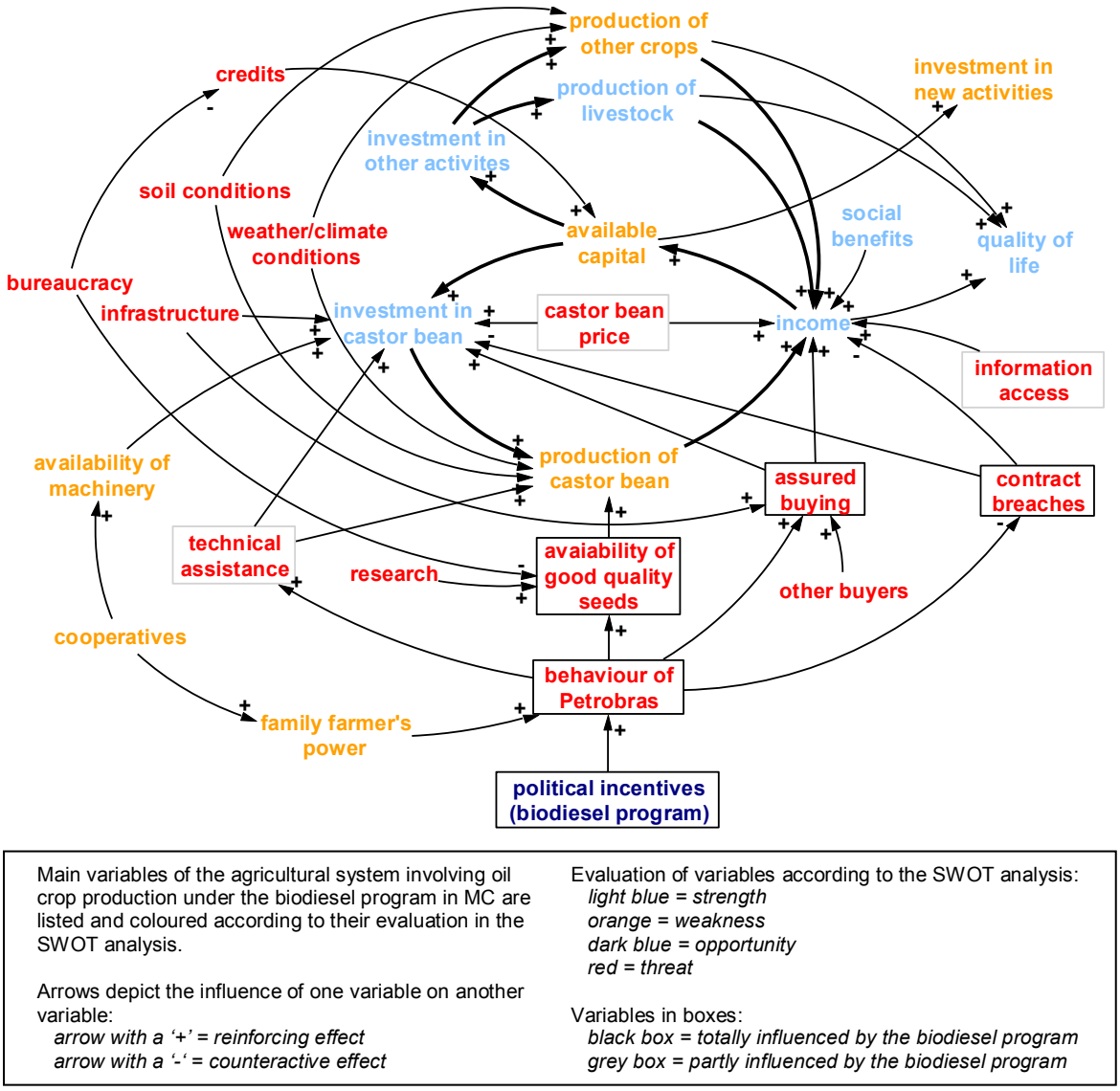


Figure 65: SWOT analysis of the System Thinking model for MC

One of the internal weaknesses is the availability of capital due to the difficulties in obtaining credits from the bank. However, it is sufficient for the necessary investments and production inputs. Some farmers are even able to invest in *new activities* which are due to their newness still a weakness. Another weakness is the poor production of castor beans caused by recent external difficulties: bad weather conditions, late delivery of seeds, bad seed quality, and poor technical assistance due to a contract partner change. The absence of a cooperative makes it difficult to access machinery as needed. Only a few farmers have their own tractor; others borrow from neighbours or the farmers' association. Farmers who are not organised in a cooperative also have lower bargaining power in contract negotiations with Petrobras.

The only opportunity granted by this system could be the political incentive, namely the biodiesel program PNPB.

Conversely, 14 external threats were identified in MC. The *behaviour of Petrobras* towards the family farmers was determined by an asymmetry in *information access* and power. For the high share of low educated or even illiterate farmers it is difficult to obtain the required information about markets, market prices, contract conditions or their rights. Petrobras did not fulfil the contracts. They delivered the promised seeds too late and in bad quality (*availability of good quality seeds*), and they did not buy the harvest in time and for the negotiated price (*assured buying*), thereby breaching the contract (*contract breaches*). The *castor bean price* was ill-defined and in the end, was lower than expected. The contracts with the *technical assistance* partner EMATER were not renewed, and another partner was chosen, resulting in a lower quality of the service. The *research* and development of seeds lacks in intensity and success. The contract prohibited *other buyers* for the castor bean harvest, but when Petrobras did not buy, farmers sought out alternatives and often accepted worse conditions which meant less support through technical assistance, inputs, transportation, and delayed payment. The *weather and climate conditions* in the region are very dry which makes it difficult to grow crops. Even more difficult for the castor bean production was a very dry period during the rainy season in 2010. *Soil conditions* are rather poor in terms of nutrients and low pH-values, which results in a high lime demand to buffer the acidic conditions. The limited transport *infrastructure* makes it difficult to approach every farmer. Farmers without good access to the road network are difficult to reach and therefore not profitable for Petrobras, which is why those farmers did not invest in the production of castor beans. Last but not least, bureaucratic obstacles (*bureaucracy*) make it difficult for the farmers to obtain bank loans (*credits*) and thereby raise their investment potential and to receive the castor bean seeds.

The distribution of the colours in the System Thinking model shows in the upper right part of the diagram mainly light blue (opportunities) and some orange variables (weaknesses). This part can be defined as the core agricultural complex, which is evaluated as generally positive. The upper left part of the diagram shows red external threats, which are either ecological parameters or belong to public duties. The lower left part contains variables connected to the existence of a cooperative, which are marked in orange. This part of the system is very weak at the moment due to the absence of a cooperative. Most interesting are the variables displayed in a grey or black box in the lower right and centre of the diagram. These variables belong to the PNPB and are all coloured in red (threats) or orange (weaknesses). This means that the PNPB produced threats rather than the expected positive effects into the system. Likewise, the PNPB does not mitigate the existing threats in the upper left part of the model.

Another important finding is that the system contains two reinforcing feedback loops in the upper right part of the diagram. These feedback loops can absorb and boost a disturbance (e.g., contract breach) very easily and thereby unbalance the system. There is no balancing loop to counteract this development. Thus, although the biodiesel program can be regarded

as external opportunity, due to the many implementation problems that are assessed as external threats with negligible internal strengths and external opportunities, the initially good approach is instead transformed into an external hazard to the resilience of the core agricultural system.

Figure 66 summarises the strengths, weaknesses, opportunities, and threats of the system in MC in the SWOT matrix.

Internal variables	**Strengths (7)** • diversity • investment in castor bean • investment in other activities • production of livestock • social benefits • income • quality of life	**Weaknesses (7)** • production of castor bean • production of other crops • *(non-)** availability of machinery • *(non-existent)** cooperatives • family farmer's power • *(not)** available capital • investment in new activities
External variables	**Opportunities (1)** • political incentives (biodiesel program)	**Threats (14)** • behaviour of Petrobras • information access • availability of good quality seeds • *(not)** assured buying • contract breaches • castor bean price • technical assistance • research • other buyers • weather/climate conditions • soil conditions • infrastructure • bureaucracy • credits

Figure 66: SWOT matrix of the system in MC

(**Italic letters mark additional information that are not displayed in the System Thinking diagram)*

6.2.2 Chapada Gaúcha

The System Thinking model in CG contains many more blue variables (strengths and opportunities) than in MC (Figure 67). No weaknesses and just two threats are accompanied by 14 strengths and 10 opportunities. In CG, some variables are internalized into the core agricultural system which are external in MC (*technical assistance*, *bureaucracy*, *credits*). Three variables are directly connected to the PNPB: *political incentives (biodiesel program)*, *behaviour of Petrobras,* and *contract breaches*. The other variables are due to historically developed production chains relatively independent of the PNPB.

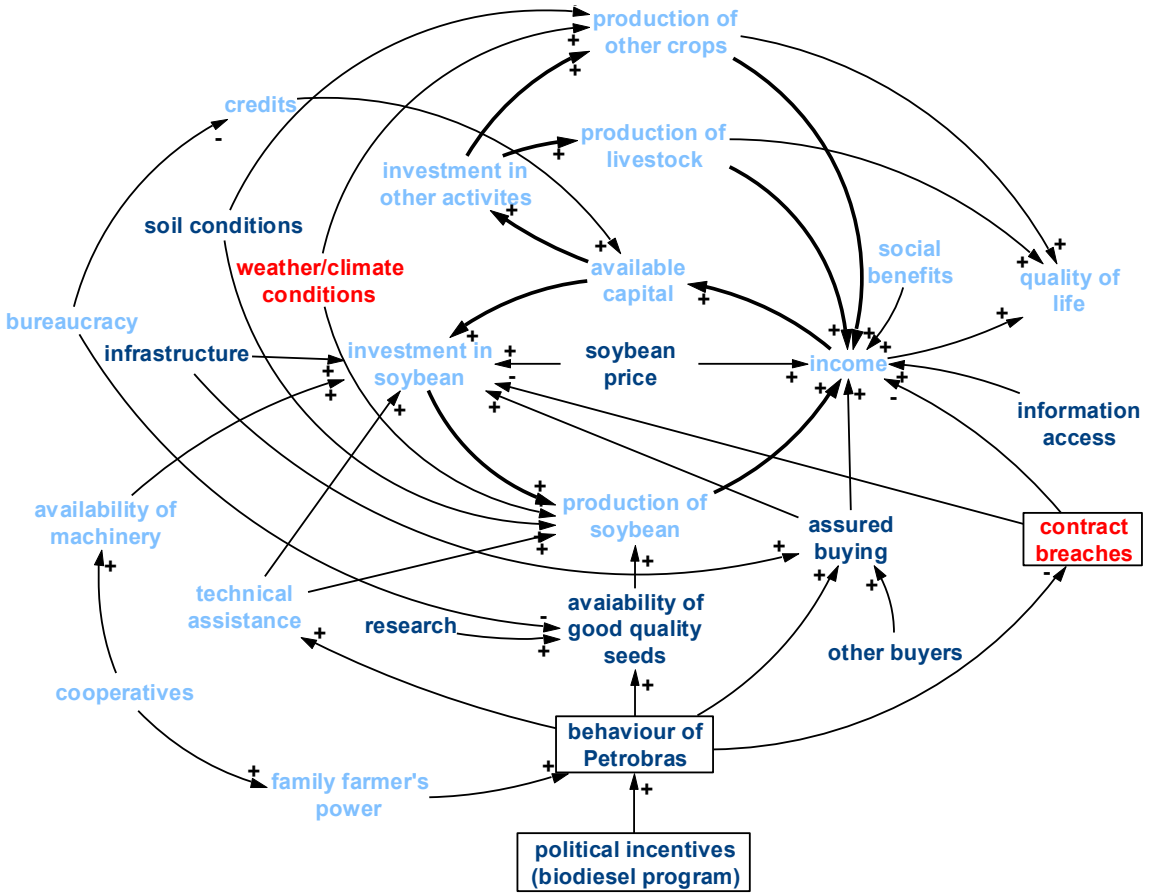


Figure 67: SWOT analysis of the System Thinking model for CG

Because in CG farmers are organised in a *cooperative* that functions effectively and has a well organised management (strength), the *availability of machinery* and *family farmers' power* are strong as well. *Technical assistance* and *bureaucracy* are integrated into the cooperative.

Moreover, recently a credit cooperative was founded by the farmers and provides easy access to *credits*. Thus, these variables (*technical assistance*, *bureaucracy*, *credits*) are part of the inner core system and are similarly valued as positive because they can be influenced by the farmers and work well. Nevertheless, the positive valued credits come along with a high rate of indebtedness and might turn into a weakness in case of a total crop or market failure which at the moment does not seem to be likely. Stronger farmers' power leads to an improved influence on the *behaviour of Petrobras* in negotiations. Thus, towards the farmers in CG, Petrobras behaves mainly positively. Some variables that were evaluated as problems in MC are opportunities for CG: *research*, *availability of good quality seeds*, *assured buying*, *information access*, *soybean price,* and traffic *infrastructure*. This is because soybeans were produced in CG even before the PNPB started. The production chain was already well organised. Thus the farmers are less dependent on Petrobras as a buyer because they have other reliable buyers; only *contract breaches* and bad *weather and climate conditions* are seen as external threats.

Overall, the system in CG has many internal strengths and external opportunities (see Figure 68). Just three variables belong directly to the PNBP (framed variables); regardless, the system has extensively more supportive variables than the system in MC.

Both systems are hard to compare as they had totally different preconditions even before they participated in the PNPB. As an example, the economic development level and market integration vary between the regions and are most likely reasons for different outcomes. However, the comparison of the two municipalities was not the aim of the SWOT analysis but the implications of the participation in the PNPB on the systems stability was evaluated independently.

Internal variables	**Strengths (16)** • cooperatives • availability of machinery • technical assistance • family farmer's power • bureaucracy • credits • investment in soybean • investment in other activities • crop rotation • production of soybean • production of other crops • production of livestock • social benefits • income • available capital • quality of life	**Weaknesses (0)**
External variables	**Opportunities (10)** • political incentives (biodiesel program) • behaviour of Petrobras • research • availability of good quality seeds • infrastructure • soil conditions • information access • other buyers • assured buying • soybean price	**Threats (2)** • weather/climate conditions • contract breaches

Figure 68: SWOT matrix of system in CG

7 SYNTHESIS AND CONCLUSION

The objective of this study was to evaluate if the biodiesel program PNPB alleviates the precarious situation of poor family farmers substantially and leads to more resilient family farming systems in northern Minas Gerais. Therefore, the agricultural systems in two municipalities where family farmers were participating in the PNPB were studied in-depth and also insights from another four rural municipalities in the area were integrated. Through workshops, interviews, and a survey a detailed picture of the circumstances, preconditions, and interrelations within the agricultural systems was drawn.

The following sections comprise a general evaluation of the PNPB in northern Minas Gerais followed by a resilience analysis of the family farming systems which integrate the production of oil crops for the PNPB. From that, a selection of possible alternative development strategies is developed.

7.1 Consequences of biodiesel production in northern Minas Gerais

7.1.1 Evaluation of the PNPB

The evolution of the participation of family farmers from northern Minas Gerais in the PNPB has a clear trend: after a first euphoria, difficulties during the production and marketing process left the farmers back in disappointment and the number of participating farmers went down. Especially very small farmers like those in Varzelândia, Montezuma, Rio Pardo de Minas, and Taiobeiras quit the cultivation of castor beans after the first unsuccessful attempt. As they mostly planted less than 5 ha given that most of them own less than 20 ha in total, the harvest yields were small and the collection was not profitable for Petrobras. The development in Matias Cardoso, where farmers planted around 5.5 ha on average, was a little different. As more farmers took part in the program than in other municipalities, it was more profitable for Petrobras to provide seeds, bags, and technical assistance and collect the harvest. Nevertheless, more than half of the participating farmers had already dropped out of the program in 2012. As the recruitment process of Petrobras in 2013 was not successful in the long term, the area used for castor bean plantation was further reduced. The situation in Chapada Gaúcha, a municipality with larger family farms, was totally different. Their cooperative COOAPI had a looser contract with Petrobras and the cultivation of soybeans was not dependent on the PNPB. For Petrobras, COOAPI was the perfect contract partner and the collaboration was continued.

The observed trend in Minas Gerais is in line with the national development. Family farmers could not be integrated into the program as it was intended. Ten years after the launch of the program, only half of the target number of family farmers are participating and those who are integrated into the production of raw material are struggling with a lot of problems. Recently, the numbers of participating family farmers and purchased raw material have gone further down. Because of the difficult integration of family farmers with other oil crops than soybeans into the biodiesel production chain, the legislation was changed in 2014 and now allows to multiply expenditures towards family farmers with a factor up to four (Tavares, 2015). This measure reduced the costs for biodiesel companies and made it easier to fulfil the requirements for tax reductions. In the end, less family farmers are needed. Moreover, through tax reductions on raw material from non-family farms which are regulated in decree Nº 7.768 from 27th of June 2012 (Presidência da República, 2012), the purchase from these larger farms is financially supported.

These findings lead to the conclusion that the PNPB has failed its goal of providing a sustainable income source for the poorest family farmers in the countryside. This failure was already predicted by Faria (2009) and Garzez and Viana (2009) who also claim that the objective of promoting social inclusion and the diversification of feedstock has not been fulfilled. This study proves the prediction. The target group is not reached through the PNPB (cf. V. H. A. D. Souza, Santos, Campos, & Carolino, 2016).

The main obstacles for the success of the PNPB are the following:

(i) The biodiesel industry and the family farmers represent two different production logics. Both have different aims.

(ii) The organisation is centralised and sales and trade happen on a national rather than on a local level which results in power and information inequalities.

(iii) Low-educated family farmers are at the mercy of the market.

(iv) The program creates a dependence relation and does not foster agricultural production beyond the frames of the program.

(v) Communication problems and contract breaches cause distrust.

(vi) Income is guaranteed only as long as the program exists and contracts are complied with.

(vii) The program only focuses on one crop in each region which, in the case of castor bean, is not yet fully adapted to the biophysical and agricultural conditions in the north of Minas Gerais.

(viii) Local preconditions are very diverse and not properly considered so that farmers do not have equal opportunities of benefiting from the program.

(ix) Adverse weather conditions were not foreseen and could not be dealt with by the program implementers.

(x) The program strengthened large-scale farmers in the southeast, northeast and central regions of Brazil, whereas small-scale farmers were not competitive enough to benefit from the program (cf. J. Hall et al., 2009; Lehtonen, 2011).

(xi) Last but not least, other pressing problems (education, infrastructure, health) are not addressed by the program.

Many of these implementation problems were not anticipated when the program was initiated and are partly explainable by the inexperience of Petrobras with family farmers (cf. Watanabe et al., 2012). Apart from that, rural programs which focus on a specific crop as a catch-all solution often seem to have implementation problems, as exemplified by Hunsberger (2010) in her study of jatropha production in Kenya.

Culture, tradition, literacy rate, infrastructure, weather etc. are decisive factors in shaping the performance of the PNPB. Watanabe et al. (2012) came to a similar conclusion and stated that the existence of the already into the market integrated cooperative COOAPI in Chapada Gaúcha (CG) was a perfect precondition for the production of raw material for the biodiesel factory in Montes Claros. However, they draw a conclusion from the viewpoint of the industry: family farmers must prepare themselves to contribute their part and fit into the production chain for successful biodiesel production (Watanabe et al., 2012).

Without soybeans, the production of biodiesel would not have grown as much and as fast as it did (Giersdorf, 2013) and the blending quote would not have been reached. From the beginning of the program soybeans were considered to have great potential for the production of biodiesel in Brazil (Holanda, 2004; Vilela & Araujo, 2006). Thus, its production was supported by tax reductions and other incentives (Giersdorf, 2013).

Also Petrobras uses mostly soybeans (purchased from COOAPI) as raw material for biodiesel. However, soybeans cannot be grown by single small family farmers in Minas Gerais. The production is highly mechanised and large fields are needed for a profitable production. COOAPI shows how family farmers can participate in the soybean production. The organisation in a cooperative lets the farmers benefit from economies of scale and simultaneously from the status as family farmers as which they are classified by law. This shows that the PNPB is supporting well-off farmers. This trend was also expected by the OECD (2009), who predicted that market-oriented family farmers who are already integrated into production chains will profit more than small subsistence family farmers. Wilkinson and Herrera

(2010) and Borras Jr. et al. (2010) see an increasing dominance of large-scale agribusinesses producing soy for the PNPB. The main production areas of soybeans lie in the center-west, southwest and south (cf. Figure 4, page 13). These are not the regions where the target group of the PNPB, family farmers from poor regions in the north, northeast and the semi-arid regions, lives (Nunes, Justo, & Rodrigues, 2014).

Economies of scale often put social benefits under pressure (J. Hall et al., 2009). According to Wilkinson und Herrera (2010), the rising demand for soy has already caused land concentration and weakened the position of family farmers. This phenomena can be observed for small soybean growers in the south of Brazil (Schaffel et al., 2012). Following Borras Jr. et al. (2010), the dominance of soy as main raw material is a consequence of large-scale agribusiness' lobby work. Besides agribusinesses the business association Ubrabio (an association of producers of biodiesel, inputs, equipment, technology, and other services related to the biodiesel production chain) influences the development of the biodiesel program (Duarte, 2009). As biodiesel companies see their economic profitability at risk through the obligation to buy raw material from family farmers, they resist against the *Social Fuel Seal* (Repórter Brasil, 2010a). Many of the changes the PNPB has undergone during the last years are supporting the interest of the biodiesel producers (Schaffel et al., 2012). Also the Ministry of Agriculture, Livestock and Supply (MAPA) questions the economic feasibility of biodiesel production based on raw material from family farmers. According to Giersdorf (2013, p. 117) the ministry "can be considered part of the 'Biodiesel Agribusiness Coalition' that stresses the needs and demands of the large scale oilseed and biodiesel production units, concentrated in the Centre-South region." The introduction of B5 (blending quota of 5% biodiesel) in 2010 was also pushed by this lobby (Repórter Brasil, 2010a; Vedana, 2010).

According to Wilkinson and Herrera (2010), agro-industrial farmers might overtake the supply of raw material for biodiesel and profit more than the program's target group of family farmers. J. Hall et al. (2009) found some indicators that the biodiesel program evolves similar to the ethanol program PROALCOOL with only large-scale producers (cf. Repórter Brasil, 2010b; Schaffel et al., 2012; Wilkinson & Herrera, 2010). Although the social inclusion of family farmers was no direct aim of PROALCOOL, they were integrated in the beginning. Now they are virtually excluded.

This study also indicates that the development of the PNPB points in a direction of general up-scaling of production. The dominance of large-scale producers and the concentration of participating farmers in the center-west, southwest, and south instead of in northern Brazil shows that the goal of the PNPB is reversed.

7.1.2 Consequences for family farmers' resilience

Besides this critique considering the implementation of the PNPB this study aims to evaluate the effects of the biodiesel program on participating family farmers and their agricultural systems.

With the SWOT analysis it is possible to analyse the economic resilience of the agricultural systems which integrate oil crops for the PNPB in Matias Cardoso and Chapada Gaúcha. Therefore the system's elements were classified into strengths, weaknesses, opportunities, and threats. Figure 69 shows a comparison of the distribution of the variables in Matias Cardoso (MC) and Chapada Gaúcha (CG) in the SWOT matrix.

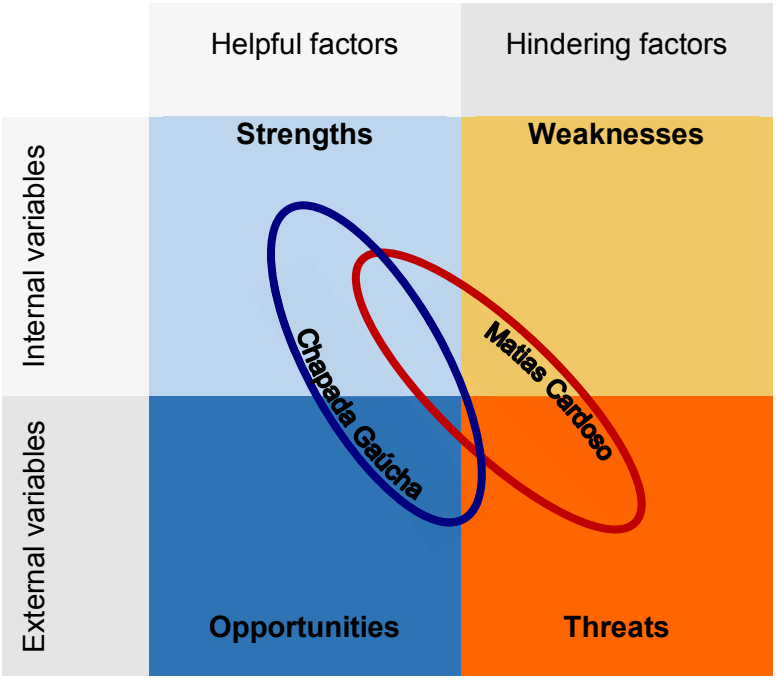


Figure 69: Schematic distribution of variables in MC and CG in the SWOT matrix
(The ellipses depict how the variables of the System Thinking models for MC and CG are distributed to the four categories of the SWOT matrix.)

Most variables in MC are categorised as hindering factors and are thus to be found in the right part of Figure 69 because the agricultural system which participates in the PNPB is characterised in MC by a lot of threats and weaknesses and a minor number of strengths. All strengths are to be found in the core system (which does not contain variables belonging to the PNPB). All variables belonging to the PNPB complex are evaluated as threats or weaknesses. Weaknesses and threats must either be counterbalanced by or converted into strengths and opportunities for the positive development of the system.

The structure of the system with its two reinforcing feedback loops amplifies any impulse that is brought into the system. Hence, a disturbance or change (e.g. a change within the PNPB, weather conditions etc.) can contribute to a destabilization of the system and easily bring it out of balance.

This means that the PNPB with all its difficulties more likely threatens the agricultural system than stabilises it. Instability is the opposite of resilience. Thus, the PNPB makes the agricultural system in MC less resilient because the program only raises the number of threats in the system, does not affect already existing external threats (like weather uncertainties), and internal weaknesses are not turned into strengths. Instead, the agricultural system becomes more vulnerable.

Besides the evidence of the SWOT analysis the system in MC also shows only a few factors identified for resilient farm systems (cf. Chapter 2.4). Other factors are lacking e.g. family farmers have a low education level, no strong connections with their neighbours (no cooperative), no reliable business partner and little own resources. On the other hand, their diversity index of production is higher than in CG and as they already survived and recovered from several periods of misery that happened when other governmental programs ended (pig fattening program, cotton production) they proved to be able to develop new ideas and strategies (recent ideas were to establish an irrigation system and to organise in a cooperative). Moreover, sometimes shocks (e.g. contract difficulties between farmers and Petrobras) seem to trigger farmers' inventiveness in finding alternatives to the PNPB[20]. Thus, the core system has demonstrated its resilience. Although the economic level remains low and farmers do not earn a high income in this core system, they can make enough money to survive (cf. G. M. Souza, 2012).

Past governmental programs could also be defined as subsystems and their resilience could be evaluated. However, as they failed (for a variety of reasons), it is obvious that they were not resilient. Also the PNPB (defined and evaluated as subsystem) does not show a high resilience because all variables belonging directly or indirectly to the PNPB are evaluated as threats or weaknesses.

In the well-functioning family farming system in CG, the focal point of the variables lies in the strengths block on the left side of the diagram (Figure 69). Both the core system and the extended system with the PNPB are characterised by almost only strengths and opportunities. The participation in the PNPB did not threaten the agricultural system. As the core system itself is already strong, the farmers did neither become dependent on the PNPB nor did the PNPB make the system more or less resilient. Through a lot of strengths and no weaknesses, the system is much more resilient against adverse events and shocks than the system in MC provided that the market system is maintained in its current form. Moreover, the system in CG

[20]During the future scenario workshop several farmers emphasised the mobilisation of family farmers by the PNPB as positive. Even though the participation in the program ended, it was the initial point to become active and try something new.

shows many resilience indicators (cf. Chapter 2.4): settlers learned to survive in a new environment and adapted to new circumstances, they invented an innovative grass seed production, they have modern equipment for field work, are well-educated, have several economic pillars (medium diversification index), a strong and diverse network of contract partners, and good teamwork in their cooperative.

However, the analysis concentrated on the social and economic aspects of resilience as the PNPB also focuses on these aspects. The ecological resilience of soybean cultivation in monocultures may be questioned if the side effects of intense farming (soil compaction and erosion caused by heavy agricultural machines and impacts on natural fauna and flora through the application of agro-toxicants) are considered. Kohlhepp and Anhuf (2010) already mention these impacts for the *campos cerrados* (the savannahs in Central-Brazil). Other authors also evaluate monocultures as less ecological resilient (e.g. Berkes, 2010; Holling & Meffe, 1996; Lin, 2011).

This study shows that family farmers who live in an agricultural system with a resilient low standard of living do not become more resilient through the participation in the PNPB. For those farmers (MC), the integration of oil crops for biodiesel production can even be a threat for their resilience, e.g. family farmers can be excluded from the biodiesel production chain if they do not fulfil certain economic criteria (cf. Laabs, 2016). But the PNPB can have a positive effect as well: the core system itself becomes more resilient and the abilities of the farmers to adapt to new circumstances grow. A transformation of the system towards a system without PNPB but with alternative opportunities for income could be more resilient than the current system.

Another agricultural system which is not much affected by the program and whose structure is very similar to that in Matias Cardoso is the system in Varzelândia. Family farmers here rely on their production diversity and self-supply capacity. The PNPB did not offer much of a chance to them so they quit producing castor beans after one season. As they did not invest much or became dependent on the income from castor beans, the short participation in the PNPB did not cause any negative effects to their system's resilience. Although their resilience was not evaluated in detail, it can be regarded as high due to their food self-sufficiency and independence of powerful contract partners.

Of course it is much easier to integrate family farmers into the biodiesel production chain if they are already organised in cooperatives and have strong institutional arrangements (cf. Watanabe et al., 2012). Originally, however, farmers like those in CG were not the target group of the PNPB. The program wanted to reach underprivileged poor farmers who truly have a low income level. Yet, a focus shift towards already well-organised and economically advantaged soybean family farmers has taken place. But despite the question if those historically grown

structures can be implemented in every region within a short timescale (e.g. farmers in Varzelândia described themselves as very individualistic) it has to be asked whether it is desirable to fit family farmers into the economic market.

According to Dauvergne and Neville (2010), the production and consumption patterns of biofuels bear the risk for already marginalized people to be left even further behind. Groups opposing the agrarian capitalism paradigm (e.g. *Via Campesina*, parts of the *Movimento dos Trabalhadores Rurais Sem Terra*) see the emerging biofuel complex as a barrier for the development of other pathways for a localized sustainable food and fuel production which would lead to more sovereignty. Within the biodiesel program, family farmers are limited to just producing raw material for biodiesel production instead of being part of the value added production chain (cf. Bastos Lima, 2013; Garcez & Vianna, 2009). In this way these farmers are kept in a state of underdevelopment. Because of this, these poor and underprivileged family farmers have to find other possibilities to strengthen themselves.

Through the analysis performed in this work it was shown that governmental programs do not always result in a better situation than before - i.e., make the system they want to affect more resilient. In fact, these programs can be dangerous and cause more damage than they help (cf. Ostrom, 2007). Although subsidies aim to help farmers to maintain their livelihoods, the reality often looks different and large agribusinesses benefit more than small family farms (Robin, Wolcott, & Quintela, 2003). Myers and Kent (2001) thus speak of perverse subsidies that beside being economically costly and creating economic dependencies can cause environmental damage because higher yields are subsidised at the expense of contaminated water, soil erosion, deforestation, and land clearing.

Rural development programs in Brazil often had a similar effect. According to Martins (1981, 1989) in Schneider (2007), programs with the purpose of ‘helping others’ often mutated to any form of dominion and control over others in the Brazilian history. According to him, this also happened in the settlements of the agrarian reform. As several studies on the development issue revealed, the efficient and effective success of such programs depends on the sustainability that is reached, i.e., that the effect is lasting and does not retrocede to the starting point after the program ends (Schneider, 2007).

Under favourable conditions and for a short time, the biodiesel program can serve the purpose to generate income, but it is far from sustaining family farmers over time. It does not contribute to the improvement of living conditions (no participation on a level playing field, health and education system are not effected). It just focuses on economic aspects, while ecological and social aspects are neglected (cf. Schaffel et al., 2012).

7.2 Methodological insights

The complexity of the research topic and the dynamics in the field required a mix of different methods. A linear research design was not applicable but the insights gained required a permanent adaptation of the methods during the process and a multi-dimensional research design. The combination of qualitative and quantitative methods led to a holistic view and resilience evaluation of the agricultural system that involves oil crop production under the PNPB. The methodological learning effects and limits will be described below. Figure 70 gives an overview of the research development and the key insights of each research phase.

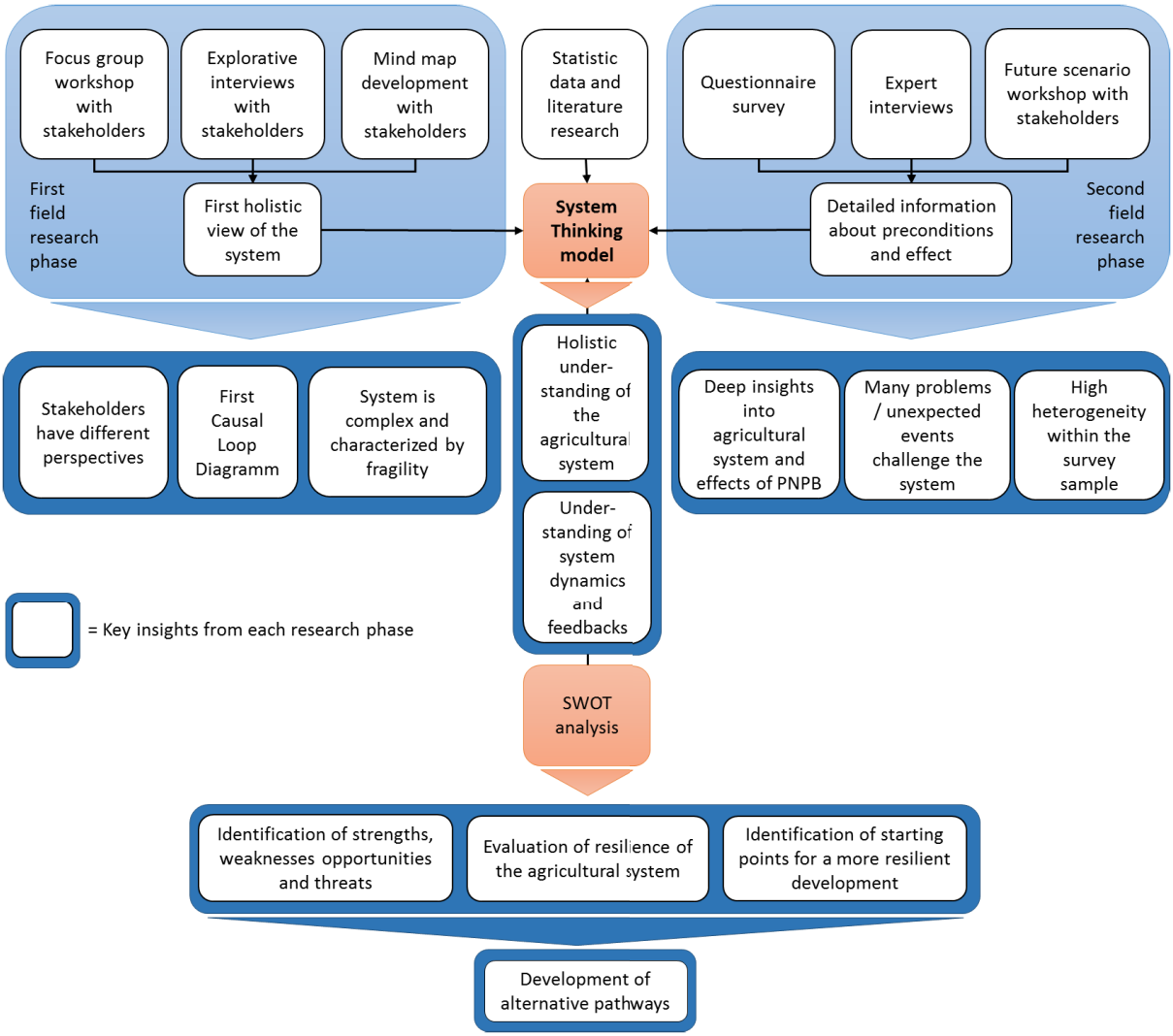


Figure 70: Research development and key insights of each research phase

The focus group workshop was a good introduction and gave an overview of the research topic. However, the selection of participants delimitated the views and topics that came up in the workshop to the mindsets of participants. The same applies to the explorative interviews and the mind map development with the stakeholders. Nevertheless, the number and diversity of different stakeholders involved assured a first holistic view of the system and a visualization of current difficulties and lines of conflict between different stakeholders. The research for

statistical data and other literature contextualised the overview. The first Causal Loop Diagram showed a complex and fragile system.

With the questionnaire survey, a deeper insight into the reality of rural life including economic data, farm structure, and quality of life was gathered. Moreover, the production chain of castor beans and soybeans including its recent problems were understood in detail. Given that the survey was very time consuming due to the fact that every interview had to be done personally and farmers are distributed over a large area, the sample was relatively small. This and the circumstance that the data were very heterogeneous might be the reasons for the fact that only obvious correlations between variables met the level of significance of 5%. Furthermore, it has to be kept in mind that many family farmers (especially in Matias Cardoso) did not keep records and hence the economic data must be treated with caution. A key insight of the research in 2012 was that the castor bean growing family farmers were challenged by many unexpected difficulties that prevented the system to run smoothly.

This insight, the difficulty to quantify especially soft variables and qualitative relations in the System Thinking model and the fact that due to the short history of the biodiesel program, no time series for validation were available, led to the insight that it was infeasible and inappropriate to build a System Dynamics model. Inappropriate insofar as external unexpected events have more power over the system's behaviour than internal interrelations. Thus, the development of the system cannot be forecasted by simulation runs. Instead, the System Thinking model was concretised and a SWOT analysis was applied for the future forecast.

The classification of the system elements into strengths, weaknesses, opportunities, and threats depicts the present condition of the system and out of this allows for a prediction for the future. With the holistic view and understanding of the system dynamics provided by the survey and summarised by the System Thinking model and the future scenario workshop, the resilience of the agricultural system that involves oil crop production under the PNPB could be evaluated with the help of the SWOT analysis. The negative impact of the PNPB on the resilience of the system was shown and variables that make the system more resilient or less fragile against disturbances from outside were identified. However, the analysis concentrated on the social and economic aspects of resilience as they were the focus of this research. Economically and socially the agricultural system in Chapada Gaúcha with its cooperative and the well-structured management is more resilient than the system in Matias Cardoso. This presupposes, however, that the market system is maintained in its current form. Ecologically this rating must be questioned since it is known that monocultures (like those in Chapada Gaúcha) are less ecological resilient (e.g. Berkes, 2010; Holling & Meffe, 1996; Lin, 2011). In order to assess the environmental impacts of the agricultural systems, a much more comprehensive study would have had to be carried out, which was beyond the scope of this work.

With the SWOT analysis it was possible to evaluate the knowledge gained in the previous research steps, which consisted of a combination of qualitative and quantitative data. Although the data basis was already broad it would of course be desirable to have an even broader knowledge base especially for quantitative data. The same applies for the System Thinking model. But given the fact that the data acquisition was limited by the circumstances in the field, the combination of these two methods led to a satisfying outcome. The system was understood in a holistic way including its reinforcing forces, dependencies and hierarchies and it was possible to identify starting points for more resilient pathways. Moreover, the presentation of strengths, weaknesses, opportunities, and threats is illustrative and easy to understand for stakeholders, policy makers and scientist.

The combination of methods used allows for an effective and pragmatic evaluation of the resilience of farming systems without modelling and at manageable costs. It is easy to learn and can be used in the field with reasonable effort. Data to be integrated are easily collected and the method can be transferred to other systems. Future research should consider this possibility and use this method to develop a more significant database of systems that have been evaluated for resilience to be used for comparisons. For a better comparison, the alternatives proposed in the following chapter, the agricultural system in Varzelândia, as well as other agricultural communities who integrate the production of oil crops for biodiesel, for example in the south or far north of Brazil, should be evaluated. Moreover, the applied method combination would be applicable to other agricultural programs as well. It would be of high value if other programs were tested ahead of implementation.

7.3 Stronger resilience and possible alternatives

Some factors which are, according to Darnhofer (2010), relevant for a resilient farm system are already present in CG und MC. Others can be improved. Farmers in CG could especially lower their debt level and rise their diversity of crops to become even more resilient. Moreover, the ecological resilience should be enhanced. In MC there are as well several weak points. Farmers' missing knowledge and information sources, their fragile networks and lack of cooperation, and their low self-organisation and autonomy degree deteriorate their resilience.

As shown in this study, inclusion into the biodiesel production process was no solution for the farmers in MC, because it is heavily dependent on given conditions. This underlines Helmsings and Vellemas (2011) position of contextual conditions and social embedding being decisive and need to be brought into focus. Beyond these findings, it has to be asked in which system family farmers want to be included and also who should govern the process. As the top-down approach failed, and this is also happening in other regions (India, Africa), others concepts

seem to be needed to meet family farmers' reality and increase their resilience. According to the UN Special Rapporteur on the right to food Olivier De Schutter (2014), the productivist paradigm must be replaced by a new paradigm that focuses on well-being, resilience and sustainability to realise the right to adequate food.

To strengthen the resilience of the family farming system in MC and to have more strengths and less weaknesses in the system this study reveals several possibilities for action:

(i) Public policies can provide better conditions and thus opportunities for the farmers.

(ii) Inner weaknesses can be transformed into strengths.

(iii) External variables can be integrated into the system and hence be better influenced to transform threats into strengths.

(iv) The system can be adapted to external threats by finding possibilities to deal with them productively.

(v) A diversification of production can strengthen the economic stability.

(vi) An increase of farmers' autonomy can make them less dependent on outer conditions and contract partners.

In the following, these strategies will be concretised and underpinned with practical examples.

(i) Investment in infrastructure, packaging and processing facilities, as well as distribution channels can enhance the local food systems. Supportive policies and reforms across all relevant sectors (agriculture, rural development, health, education and social protection) are needed to ensure the right on food (De Schutter, 2014). The bettering of infrastructure and education facilities through governmental action would make it easier for family farmers to get access to information and markets.

An improvement of existing programs like the PNPB, the implementation of new programs, or the investment in research can provide new economic opportunities to the farmers. The government can encourage farmers to participate in programs which do not have an industrial partner to avoid the clash of two production logics where the industry has an economic interest that cannot be fulfilled by the farmers. The participation of some farmers in the region in the national Food Acquisition Program (*Programa de Aquisição de Alimentos – PAA*) or the National School Meals Program (*Programa Nacional de Alimentação Escolar – PNAE*), a governmental program for the delivery of vegetables for the local school lunch, can be seen as a strategy to have reliable public buyers and to not depend on one (industrial) buyer. These activities can be implemented locally.

However, under the current political situation, a governmental support for family famers is more than questionable. After president Dilma Rousseff was removed from office in May 2016 and Michel Temer became interim president, he immediately merged the Ministry of Agrarian Development (MDA) with the Ministry of Social Development and Fight against Hunger (MDS) (Kern, 2016), which is a downgrade of its competence and influence. The national council on sustainable rural development (CONDRAF) criticised this decision with reference to the important role the MDA plays for the family farming (Conferência Nacional de Assistência Técnica e Extensão Rural, 2016).

(ii) Founding a cooperative can strengthen the collaboration and farmers can find collective solutions for their inner weaknesses, e.g. lack of machinery and investment capital. Working together would build up family farmers' innate abilities of cooperation and organisation and thus their power towards external contract partners. As two thirds of the interviewed farmers in MC wish to take part in a cooperative and some are already thinking about affiliating in a cooperative, the implementation of this option seems to be realistic. In this context it is important that the impulse for the establishment of a cooperative does not come from external benefactors, but is guided by the beneficiaries themselves to turn them "into their own agents of change" (Schneider, 2007, p. 25), which generally is described as bottom-up. Solidarity-based economy evolved in Brazil since the 1980s and is supported by public programs which are coordinated by the National Secretary for Solidarity-based Economy (Secretaria Nacional de Economia Solidária – SENAES). This bottom-up approach became more prevalent during the economic crisis with growing unemployment after the end of the dictatorship in 1985 (Ströh, 2010). The current situation in Brazil might have comparable effects and people already begin to rely more on their own strengths and partnerships than on public programs. For example, rural people living in the Cerrado met up with an associate of CAA/NM in February 2017 to highlight the need of local cooperation and to evaluate and strengthen the local potential of affiliating and working together (CAA, 2017a). The resilience of cities can also be improved by the strengthening of local food systems (De Schutter, 2014).

(iii) Ostrom (2007) found out that self-governing systems where farmers affiliate with each other are more efficient and stable than systems that are technically supported from outside the community. A cooperative could thus integrate external variables like technical assistance, bureaucracy, and information access into the core system and have hence a better influence on them to transform them into strengths as well. According to De Schutter (2014), rural poverty and rural-to-urban migration can be reduced by allowing smallholders to organise themselves such that they can benefit from economies of scale and add value to their raw products through processing. As family farmers in the researched municipalities already help

each other with information exchange, manpower, and equipment, these attempts should be supported.

(iv) External threats like adverse weather and climate conditions can be tackled with a reorientation of production. Some farmers in MC already invest in new activities like irrigation systems to be less dependent on climatic conditions. However, irrigation has to be handled with caution because (a) drilling a well is cost intensive and there is no guarantee to find water and (b) the groundwater level might decline which has ecological impacts. In the Cerrado region, irrigated cash crop cultivation already caused water shortage and a decline of water levels in water reservoirs (Kohlhepp & Anhuf, 2010). Together with recently appearing aperiodic dry seasons, this results in increasing problems. Large-scale irrigation projects so far did rarely better the situation of small farmers with mostly large-scale agribusinesses profiting.

Another possibility would be to adapt the agricultural system to the conditions of this dry region. One concept which intensively uses this principle is agroforestry[21]. Agroforestry attempts to imitate nature. In nature, plants and animals live in communities with other species and profit from each other in growth and reproduction aspects. In a process of natural succession different communities occur and step by step the system develops to a climax stadium (Vaz, 2000). Agroforestry adopts this principle. Natural species are planted together with locally beneficial species that occur in similar natural conditions and succession stages. The pioneer of agroforestry in Brazil, Ernst Götsch, developed a system in which the different succession communities combined with management methods are used to improve soil quality, availability of nutrients, permanent soil cover, and the amount of organic material (Götsch, 1995). To achieve long-term yields, he planted e.g. elephant grass, manioc, beans, maize, pineapple, bananas, and other fruit-, nut-, and timber species in combination with native tree species (Vaz, 2000).

During the last 30 years, different agroforestry systems were developed all over the country of Brazil. Most of them have been implemented by smallholders. One example studied and evaluated by Gonçalves (2011) is situated in the *Caatinga* region with average annual rainfall of 300-800 mm. Agroforestry was considered important to combat desertification and to increase the capacity of rural communities to cope with the effects of drought (Miccolis, Vivan,

[21] Agroforestry here denominates a system which combines methods of agroecology with the plantation of trees to provide ecosystem services and to enhance food sovereignty and income of family farmers (cf. Jacobi, 2016; Leakey, 2014). Although the combined plantation of eucalyptus trees with cash crops is also referred to as agroforestry (Albuquerque, Soares, Lana, & dos Santos, 2016; Lana, Lana, Reis, & Lemes, 2016), this combination is not meant here, since field observations and the statements of local farmers attested a negative impact of eucalyptus on ground water levels.

Gonçalves, Meier, & Porro, 2011). As the geophysical conditions in that region are similar to the conditions in the researched areas of this thesis, the method will be most likely be applicable there, too. Farmers are provided with food, increased income, and fodder for livestock during dry times. Existing water is managed better and increased organic soil matter contributes to moisture retention. Another positive experience with agroforestry, which in this case was initiated by the Centre of Alternative Agriculture Vicente Nica (CAV) together with local farmers to guarantee the survival and respect local customs and the environment, was made in the valley of Jequitinhonha (Paludo & Costabeber, 2012). This semi-arid region is affected by large eucalyptus plantations and their negative effects on water availability and soil quality. However, Pereira et al. (2007) proved the implantation of agroforestry systems to be a viable strategy for the recovery and cultivation of previously degraded areas. Paludo and Costabeber (2012) describe agroforestry systems as rural development strategy. Besides the positive ecological effects, they also refer to the promising social effects. In this region, agroforestry systems serve a number of purposes and uses (e.g. human and animal food, soil cover, fertilizer, wood, firewood, medicine, handicrafts, etc.). By abandoning the model of modernised industrial agriculture, farmers were able to identify themselves with local agriculture and to reflect on new themes like social organisation, environmental issues, and collective action (Paludo & Costabeber, 2012). All these positive effects qualify agroforestry to be a viable alternative to current agricultural systems in the north of Minas Gerais. As family farmers from Matias Cardoso already expressed during the survey and in the future scenario workshop that they are willing to organise themselves in a cooperative, agroforestry could fuel this attempt.

(v) Diversifying the production by growing a higher number of food and cash crops possibly in intercropping systems makes farmers more resistant to crop and market failures. How diverse the production already is can be seen through the diversity index in MC which includes subsistence agriculture. Adopting this diversity to the variety of cash crops and dividing the cultivated area between the crops more equally would decrease family farmers' vulnerability. A tendency towards this development became obvious in the future scenario workshop where farmers stated that they wish a higher diversity.

Teixeira (2011) speaks of two options for family farmers to develop in the future: a) they could take the production agricultural model, or b) they could opt for a new agricultural model towards an agro-ecological[22] transition which should be supported by a government strategy and

[22] Agroecology is both the science and the practice of an agricultural production based on ecological knowledge and processes (see e.g. Altieri, 1987; Carroll, Vandermeer, & Rosset, 1990). Production methods resemble those of organic farming but go beyond that.

effective policies. The first option would include technical intensification, mechanisation, purchase of supplies, application of pesticides and fertilisers, debts, subsidies, fluctuating market prices, and the necessity of a production increase to be able to pay back the debt and to buy supplies for the next year. The second option has already been suggested by Mota et al. (2013) for an agricultural system with similar dependencies on industry and capital (production of tobacco and thus reduced cattle and food production) in Campo de Maio in the south of Minas Gerais. The benefits of the second approach would be independence of industry, food sovereignty, the production of healthy and nutritional food, a better environmental quality, and a recovery of degraded natural resources.

In Brazil, the expansion of agroecology started in the 1980s with J. Lutzenberger and got a boost during the last decades when it was adopted and largely integrated by public development and research institutions (Altieri & Toledo, 2011; Wezel et al., 2009). The scientific community now supports agroecology as a way to improve resilience and sustainability of food systems (Wezel & Soldat, 2009). According to Altieri & Toledo (2011, p. 587), “Agroecology-based production systems are biodiverse, resilient, energetically efficient, socially just and comprise the basis of an energy, productive and food sovereignty strategy”.

The concept encompasses three dimensions of resilience: 1.) agrobiodiversity, 2.) cultural diversity, and 3.) economic diversity (cf. Francis et al., 2003; Laschefski, 2011).

Agrobiodiversity is guaranteed by production in harmony with nature and natural resource management which enables the biodiverse agroecosystem to foster itself (Altieri, 2002; Altieri & Toledo, 2011). A range of agronomic techniques are associated with agroecology: intercropping (of preferable indigenous plants), rotation systems, recycling of manure and food scraps into fertilisers, and agroforestry (cf. De Schutter, 2014). The philosophy searches for a maximum of autonomy from financial, technical and chemical inputs (Laschefski, 2011; Wezel et al., 2009).

Cultural diversity means the integration of indigenous knowledge and traditional rites (Altieri & Toledo, 2011). Social and health benefits are also results of agroecologial practices (De Schutter, 2014).

Economic diversity guarantees that the domestic production serves as basis for food sovereignty without being dependent on a monetarised market. Only surpluses are brought to the market to complete the household. Food sovereignty and empowering peasants are important principles of agroecology (Altieri & Toledo, 2011). It offers a promising alternative especially for poor farmers in marginal environments. Farmers in Varzelândia already practise this philosophy. A high diversity of crops and food sovereignty are more important for them than short time benefits.

The aim of agroecology is not a maximum accumulation of capital through increase in production and investments but a multi-dimensional diversity. Harmful to the development and preservation of this diversity are 'monocultures of the mind' (Shiva, 1993), which narrow the view of the world, diminish the ability to think in alternatives and lead to monocultures in any form.

One example how family farmers can work with alternative and agro-ecological methods in the north of Minas Gerais is the CAA/NM (*Centro de Agricultura Alternativa do Norte de Minas*). The organisation developed as a consequence of the agricultural modernisation process which started during the 1970s and had several negative consequences for small family farmers (dos Santos et al., 2011): land concentration, displacement, impoverishment, strengthening of large scale agribusinesses, monocultures, and loss of biodiversity. Since 1985, the main spheres of activity of the CAA are the development and promotion of sustainable and agro-ecological production methods and the strengthening of traditional peoples' and communities' rights in the north of Minas Gerais (CAA, 2017b). Main principles are solidarity, autonomy and diversity. The CAA is strongly associated with the cooperative Grande Sertão (CGS), founded in 2003. The CGS includes 1500 family farmers and extractivists[23] from the region and works with the ideas developed by the CAA. At the moment, it runs a social micro-enterprise which produces and commercializes fruit pulps, honey, flour, oil, and rapadura (candy of the juice of the sugar cane) of the *Cerrado* and *Caatinga* region (Central do Cerrado, 2017; P. V. de S. Mota, 2011). These activities are adapted to the region and use the local resources and knowledge which make them very accessible for family farmers. The cooperative also provides technical assistance with a focus on holism and diversity to its members including new research results from the CAA pilot operation.

As the experiences Grande Sertão and the CAA made with the PNPB basically stayed behind the expectations, they decided not to involve too much into the program (cf. dos Santos et al., 2011). Only if castor beans can be integrated into the diversity of crops produced by a farmer he can benefit from it as an additional income source. Famers should thus not rely on this crop and the program as many problems occurring in the past could not yet be solved. Moreover, in the view of CAA a contract between family farmers and big companies is always shaped by dependence and exploitation. This does not go well together with the principles of CAA and Grande Sertão.

Another good example how agroecology can be set into practice is the non-governmental organisation CAPA (*Centro de Apoio e Promoção da Agroecologia* formerly *Centro de Apoio ao Pequeno Agricultor*) in the south of Brazil (Ide, 2008). CAPA was founded in 1978 by the

[23] In Brazil, the collection of products from nature is a common activity. Extractivism includes all activities of collecting natural products, whether these products are of animal, vegetable or mineral origin.

Evangelical Church of Lutheran Confession in Brazil (IECLB) as a reaction to the negative consequences of the *"green revolution"* for family farmers (promotion of large-scale agriculture, displacement, intensive use of agrochemicals and mechanisation which was not in compliance with the family farming concept) (CAPA, 2017). CAPA's main principle is to help families to help themselves (capacity building). The support includes advice on social and political issues as well as training and assistance on various stages of agro-ecological production and marketing (CAPA, 2017). In particular, women and young people are trained in all aspects of agriculture because only if they see a future in the countryside the project will be successful (Brot für die Welt, 2016). The families shall be enabled to produce enough food for themselves by cultivating a sufficient variety of crops and to establish market access for agro-ecological goods (Beck, Haerlin, & Richter, 2016). Social justice, biological, cultural, ethnic and religious diversity, sustainability, independence and autonomy are guiding ideas. CAPA works in the three federal states of Rio Grande do Sul, Santa Catarina and Paraná with family farmers and fishermen from different ethnical groups who are organised in groups, associations and cooperatives. The first cooperative initiated by CAPA included 46 farmers. Today some 50 employees advice approximately 7000 families. 3000 members belong to all cooperatives associated with CAPA (Beck et al., 2016; Brot für die Welt, 2016). To produce and commercialise the organic products, farmers actively participate in the decision making process (Finatto & Salamoni, 2008). Family farmers associated with CAPA grow vegetables with agro-ecological methods and mainly sell them to local farmers' markets or schools who participate in the National School Meals Program (*Programa Nacional de Alimentação Escolar – PNAE*). CAPA played an important role in the initiation of this national program. In 2000, they initiated a pilot program where school meals were exclusively prepared from agro-ecologically produced products from local small-scale farmers. Later, the Lula government supported this approach by introducing the Zero Hunger (*Fome Zero*) program and the PNAE (Beck et al., 2016). The PNAE advantages small farmers because the amount of food that can be bought from one farmer is limited. In regions where CAPA is active today, often 100% of ingredients for school meals originate from family farmers (Beck et al., 2016). Due to the work of CAPA, many family farmers noticed an increase in quality of life (health, well-being, leisure). Moreover, they have a greater diversity of food and as they grow it in their own property the quality is assured. Self-production also saves money and the surplus can be used to supplement the family income. This new sovereignty also raised farmers' self-esteem (Ide, 2008). This example shows how a bottom-up initiative can successfully involve a growing number of family farmers and let them develop their own marketing system. The initiative even drew public attention and led to the implementation of two public support programs.

These successful projects show an opportunity also for family farmers in the north of Minas Gerais. Not only can the economic stability of family farmers be strengthened by supporting

agro-ecological family farming systems, but also food security in the world can be improved: “Both the former and the new UN Special Rapporteur on the Right to Food confirmed that only smallholder farmers and agroecology can feed the world” (IFOAM, 2014, p. 14). Therefore, the improved support of smallholders is essential to achieve local food security (De Schutter, 2014).

(vi) To become less dependent on one industrial contract partner and turbulent markets, family farmers can sell their production on local markets. De Schutter (2014) shares this opinion and argues for a support of local markets. According to Kirmayer et al. (2009), it is important to establish and foster networks and relationships outside the inner group.

At the moment, in MC, farmers are already very dependent on transfer payments such as pension and social welfare programs. As long as a large part of the agricultural income depends on state programs, farmers will remain very vulnerable to changes in politics. Thus, it is important for family farmers to become more autonomous and less dependent on powerful contract partners and to obtain a higher share of the production chain. One option is already conducted in MC: farmers want to become less dependent on the continuation of the PNPB and are diversifying the circle of buyers or trying to invest in other crops and products (e.g. cattle or irrigation). In the cooperative Grande Sertão, a higher value creation is achieved by producing oil from different crops with a collectively bought oil press in order to sell it to specialised markets.

Another possibility for adding value to a raw product would be the cultivation and processing of sugarcane. In Minas Gerais this is already done by the project GAIA (Practical Action Consulting, 2009). For some already existing (in Minas Gerais and Rio Grande do Sul) and two planned micro-distilleries for ethanol (in the Dom Orione Settlement), the economic, ecologic, and social viability was proven (Júnior, Coelho, & Feil, 2009; Practical Action Consulting, 2009). As sugarcane is also feasible for intercropping systems and family farmers already have experience with growing sugar cane (farmers statement in the focus group workshop), the processing serves different demands: ethanol production for own use which creates a higher autonomy, production of the co-products sugar and rapadura, use of production residues as cattle food or fertiliser, and food self-sufficiency if food crops are cultivated along with sugar cane. Moreover, micro distilleries can create income, raise farmers’ self-esteem, and strengthen their livelihood and thus contribute to preventing rural exodus (Practical Action Consulting, 2009). The opportunity to create a decentralised biofuel supply has thus several advantages compared to the PNPB.

Despite these opportunities for family farmers and cooperatives, the lack of specific legislation for micro distilleries of ethanol “prevents access to funding, mainly due to restriction of sales,

which prevents the creation of a market" (Practical Action Consulting, 2009, p. 104). This is why the ethanol production still lies in the hands of agro-industrial farms and large companies. Ortega et al. (2007, p. 1) also attest that "ecological agricultural systems integrated with small distilleries of alcohol can have a great environmental and economical performance". But they likewise mention that besides this economically feasibility social and political forces ignore this option. This means that economic viable options exist and a higher share in the added value can be realised for family farmers, but is politically not desired.

In short, it can be recommended that in order to enhance living conditions, one needs much more than a market based one-product-only oriented policy, as Schaffel et al. (2012) also underline. The PNPB is only one example among many such projects that have been tried out and failed in recent decades in the Brazilian semiarid region. Instead, an intersectoral policy approach including agroecology and possibilities for family famers to add value to their raw products is required to actually improve the quality of life of Brazil's poor family farmers, especially those in the northeast. Such a policy could enable environmentally and socially sustainable modes of rural production and rural life-style and thus avoid the aggravation of the rural exodus.

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ANNEX

Annex 1: Questionnaire for questionnaire survey

QUESTIONÁRIO

Entrevistador _____ Data ___/___/2012 No. do Questionário _____

0 DADOS GERAIS

0.1 Nome do Agricultor / Entrevistado _____

0.2 Nome do município _____

0.3 Coordenadas GPS da propriedade rural do entrevistado _____

0.4 Hora do começo da entrevista: ___:___

0.5 Hora do fim da entrevista: ___:___

0.6 Qual é a sua relação com a terra de seu estabelecimento? Você é....
Proprietário, ☐ 1
Arrendatário, ☐ 2
Parceiro, ☐ 3
Posseiro, ☐ 4
Meeiro, ☐ 5
Assentado sem titulação definitiva, ☐ 6
ou Ocupante? ☐ 7
Outro. ☐ 8 Qual? _____

0.7 Você tem algum sócio neste seu estabelecimento?
Sim ☐ 1 Quantos? _____
Não ☐ 2

0.8 Há quanto tempo você trabalha nesta propriedade? _____ (indicar: anos ou ano em que veio)

0.9 Há quanto tempo você é agricultor? _____ (indicar: anos ou ano em que começou)

1 FAMÍLIA

Quem mora (aqui) em sua casa?
Liste os membros da sua família que moram aqui com você nesta (propriedade/casa). Começando por você...

	1.1	1.2	1.3	1.4	1.5	1.6
N°	Relação de parentesco com o entrevistado	Sexo (m/f)	Idade	Trabalha em alguma atividade agropecuária na propriedade? [Sim ou Não] Se sim: em que? [E com mamona?]	Qual foi a última série que cursou? [Escrever número da série ou ano e, se for 1, 2 ou 3, indicar o nível: fundamental ou médio]	Sabe ler e escrever? [Sim ou Não]
1						
2						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

2 UTILIZAÇÃO DAS TERRAS

2.1 Qual é a área total de sua propriedade? _____ ha

2.2 Além da sua propriedade, você arrenda alguma área de uma outra pessoa? Sim
☐ 1 Qual é o tamanho da área arrendada? _____ ha
Não ☐ 2

2.3 A área toda tem título de terra?
Sim ☐ 1
Não ☐ 2 Qual é o tamanho da área sem título? _____ ha

TABELA

2.6 Quais culturas você planta?

2.7 Quantos hectares de cada cultura você planta **hoje**?

2.8 E na **safra 2010/2011**?

2.9 Você planta esta cultura [citar cultura] consorciada com alguma outra? Qual? [preencher na tabela principal]

2.10 Você usa adubo químico?
Sim ☐ 1 Para qual cultura? [marcar com X na tabela principal]
Não ☐ 2

2.11 Você usa adubo orgânico/esterco?
Sim ☐ 1 Para qual cultura? [marcar com X na tabela principal]
Não ☐ 2

2.12 Você usa agrotóxicos / venenos como herbicidas, inseticida, fungicidas?
Sim ☐ 1 Para qual cultura? [marcar com X na tabela principal]
Não ☐ 2

2.13 Você já fez correção de solo?
Sim ☐ 1 Para qual cultura? [marcar com X na tabela principal]
Não ☐ 2

2.14 Você tem que comprar as sementes de culturas que você planta?
Sim ☐ 1 Para que cultura? [marcar com X na tabela principal]
Não ☐ 2

2.15 Você faz irrigação?
Sim ☐ 1 Para que cultura? [marcar com X na tabela principal]
Não ☐ 2

2.16 Você usa trator?
Sim ☐ 1 Quantas horas para que cultura? [preencher na tabela principal]
Não ☐ 2
Se **sim**:
2.17.a Você possui ou aluga o trator?
Possuo ☐ 1
Alugo ☐ 2 De quem? _____
[Outro] ☐ 3 Explicar: _____

2.17.b Quanto custa uma hora? R$ _____

2.17 Além dos seus familiares que moram com você, você contrata trabalhadores **permanentes/fixos** em atividades agropecuárias?
Sim ☐ 1 Quantos?
Não ☐ 2

2.18 Você contrata trabalhadores **temporários** em atividades agropecuárias?
Sim ☐ 1 Quantos? Quantos dias para quais culturas?
Não ☐ 2

2.19 Quanto você produziu na colheita 2011 por hectare? [preencher na tabela principal]

2.20 Foi uma safra normal? [preencher na tabela principal]

2.21 Quais culturas você mantém para uso próprio? [preencher na tabela principal]

2.22 Quais culturas você vende? [preencher na tabela principal]

2.23 Qual foi a renda bruta no total (preço recebido pela venda, sem descontar os custos)? [preencher na tabela principal]

2.24 Qual foi a renda líquida? [preencher na tabela principal]

2.25 Existem riscos na produção dessa cultura? Quais? [preencher na tabela principal]

	2.4	2.5	2.6	2.7	2.8	2.9	2.1(	2.1	2.1	2.1	2.14	2.15	2.16	2.17	2.18	2.1	2.2	2.21	2.22	2.23
	cultura	área **hoje**	área **2010/ 2011**	consorciados (escrever com qual cultura)	adubo químico	adubo orgânico	agrotóxicos	correção do solo	compra as sementes	irrigação	trator	trabalhadores **permanentes** N°	trabalhadores **temporários** N°	quantidade produção na **colheita 2011**?	quantidade normal?	uso próprio	culturas vendidas	renda bruta	lucro (renda líquida)	riscos
		ha	ha		x	x	x	x	x	x	horas		dias	kg kg/ha sc/ha	Sim não	x	x	R$ R$/kg	R$	
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
	pastagens																			
12																				
13																				
	silvidultura ou floresta plantada																			
14																				
15																				

	3.1	3.2	3.3	3.4	3.5	3.6	3.7		3.8	3.9	3.10
N°	**animal**	**cabeças hoje** (no total)	**cabeças em 2011** (no total)	**produtos produzidos [perguntar sempre: mais algum produto?]**	**produtos para consumo próprio**	**produtos para venda**	**quantidade vendida em 2011**		**renda bruta**	**renda liquida**	**riscos**
					X	X	quantidade	unidade	R$	R$	
1											
2											
3											
4											
5											
6											
7											
8											
9											

3 PECUÁRIA

3.1 Você cria animais?
Sim ☐ 1 Quais animais você cria? [preencher na tabela]
Não ☐ 2

3.2 Quantas cabeças de cada **hoje**? [preencher na tabela]

3.3 Quantas cabeças você tinha **em 2011**? [se não souber o número, perguntar: Era mais ou menos do que é hoje?]

3.4 Quais produtos você tira de [cada um desses animais – CITAR]? [preencher na tabela]

3.5 Quais produtos você mantém para uso próprio na família?

3.6 Quais destes produtos você vende? [preencher na tabela com X]

3.7 Em qual quantidade? [preencher na tabela]

3.8 Qual foi a renda bruta no total? [preencher na tabela]

3.9 Qual foi a renda líquida? [preencher na tabela]

3.10 Existem riscos na produção desse produto? Quais? [preencher na tabela]

4 AGROPECUÁRIA EM GERAL

4.1 Em geral, qual é a atividade da agricultura ou pecuária que tem o **maior rendimento financeiro por hectare** (que lhe dá mais renda por hectare)?

Em primeiro lugar? _____ Em segundo lugar? _____

Em terceiro lugar? _____ Em quarto lugar? _____

4.1.1 Em geral, qual é a atividade da agricultura ou pecuária mais importante para **uso próprio**, no consumo familiar?

Em primeiro lugar? _____ Em segundo lugar? _____

Em terceiro lugar? _____ Em quarto lugar? _____

4.2 Em geral, qual é a atividade da agricultura ou pecuária que dá mais **segurança** (que tem o menor risco)?

Em primeiro lugar? _____ Em segundo lugar? _____

Em terceiro lugar? _____ Em quarto lugar? _____

4.3 Em geral, qual é a atividade da agricultura ou pecuária que exige **mais trabalho**?

Em primeiro lugar? _____ Em segundo lugar? _____

Em terceiro lugar? _____ Em quarto lugar? _____

4.4 Em geral, qual é a atividade da agricultura ou pecuária com o **maior custo** de produção, no ano?

Em primeiro lugar? _____ Em segundo lugar? _____

Em terceiro lugar? _____ Em quarto lugar? _____

4.5 Nos últimos dez anos, com quais atividades da agricultura ou pecuária você ficou **mais satisfeito** financeiramente (quais deram mais lucro)?

Em primeiro lugar? _____ Por quê? _____

Em segundo lugar? _____ Por quê? _____

4.6 E com quais atividades da agricultura ou pecuária você ficou **menos satisfeito** financeiramente (quais deram mais prejuízo)?

Em primeiro lugar? _____ Por quê deu prejuízo?_____

Em segundo lugar? _____ Por quê deu prejuízo?_____

4.7 Você tem planos para uma **expansão da área** de sua propriedade hoje?
Sim ☐ 1
Não ☐ 2

Se **não**:
4.10.a Você gostaria de vender parte da área de sua propriedade?
Sim ☐ 1 Quanto de sua área você gostaria de vender?_____ ha
Não ☐ 2

4.8 Você gostaria de iniciar uma **nova cultura** ou **atividade** aqui em sua propriedade?
Sim ☐ 1 Quais? _____
Não ☐ 2

4.9 Você gostaria de expandir a área de alguma **cultura** ou **atividade** que você **já tem**?
Sim ☐ 1 Quais? _____
Não ☐ 2

4.10 Pensando nas atividades da agricultura ou pecuária na sua propriedade. Nos últimos dez anos, aconteceu algum problema que te afetou muito? [Se não entender, falar: Por exemplo, secas, perda de safras ou animais, ou queda de preço dos produtos produzidos?]

4.13.a [Perguntar para cada problema:] Como você lidou com isso?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

5 MAMONA

[SE **NÃO** PRODUZIR MAMONA:]

5.1 Você já produziu mamona alguma vez antes?
sim ☐ 1
não ☐ 2

5.2 Quais foram os motivos que lhe fizeram decidir não produzir mamona?
preço pago pelos compradores é baixo ☐ 1
as condições do contrato não são boas ☐ 2
falta de mão-de-obra ☐ 3
falta de crédito ☐ 4
falta de terra ☐ 5
outros agricultores tiveram problemas com mamona ☐ 6
a toxicidade da mamona é ruim para o gado ☐ 7
você não gosta de mamona ☐ 8
outro(s) ☐ 9
Qual(is)?_____
_____
_____

[Se não produzir mamona: pular para página **19**]

[SE PRODUZIR MAMONA:]

5.3 Em que ano você **começou** a produzir mamona? _____

5.3.1 Quando foi a **última safra** completa de mamona? (mês/ano)_____

5.4 Qual foi o **custo inicial** que você teve para começar a produção de mamona?
R$ _____

5.5 Quais são os custos anuais **por hectare** na produção de mamona?
R$/ha _____

5.5.1 Para começar a produção de mamona, você fez algum financiamento?
sim, ☐ 1
não ☐ 2

Se **sim**:
5.5.1.a Qual foi a fonte de financiamento?
Pronaf ☐ 1
Petrobras ☐ 2
Petrovasf ☐ 3
outra(s) ☐ 4
Qua(l)is?_____

5.5.1.b Qual foi o valor do crédito do financiamento? R$ _____

5.5.1.c Você já pagou/quitou esse crédito?
sim, ☐ 1
não ☐ 2

5.6 E na safra com colheita em 2012 (em este ano), quantos quilos de mamona você espera produzir? _____ kg kg/ha

5.6.1 Você está satisfeito com a renda que você obteve com a mamona?
sim, ☐ 1
não ☐ 2

Se não: Por quê?

_____
_____
_____
_____

5.6.2 Para quem você vendeu o produto da colheita da safra 2010/2011 (no ultimo ano) de mamona?

Petrobras ☐ 1 a) Quantas sacas ou kg? _____sacas kg
b) Quanto você recebeu?_____R$ R$/saca R$/kg

Petrovasf ☐ 2 c) Quantas sacas ou kg? _____sacas kg
d) Quanto você recebeu?_____R$ R$/saca R$/kg

Outro(s) ☐ 3 e) Qual(is)? _____
f) Quantas sacas ou kg? _____sacas kg
g) Quanto você recebeu?_____R$ R$/saca R$/kg

[Se vender para Petrobras]: [Se não: pular para página **13**]

5.6.3 Antes de você produzir para Petrobras, você já produzia mamona?
sim, ☐ 1 Quantos hectares de mamona você plantou em 2008?
_____ ha
não ☐ 2
[Se sim:]
5.6.3.a Para quem você vendia a mamona? _____

5.6.3.b Este comprador, te dava algum tipo de ajuda para a produção de mamona?
sim ☐ 1
não ☐ 2

[Se sim:]
5.15.b.a Que ajuda? O comprador...
fornecia assistência técnica? ☐ 1
fornecia sementes? ☐ 2
fornecia insumos? ☐ 3
ajudava na colheita? ☐ 4
fazia ou cobria o transporte? ☐ 5
ajudava na armazenagem? ☐ 6
ofereceu financiamento? ☐ 7
Prestou algum outro tipo de ajuda? ☐ 8 Qual? _____

5.6.4 Quais outras culturas você produzia no ano de 2008 (antes da produção para Petrobras)?

	A área plantada desta cultura **hoje** é maior, a mesma ou menor do que você plantava em 2008?		
cultura	maior (+)	mesma	menor (-)

5.6.5 Você criava gado no ano de 2008 (antes da produção para Petrobras)?
sim, ☐ 1 Quantas cabeças você tinha em 2008? _____
não ☐ 2

[se sim:]
5.6.6 Qual era o tamanho da área de pastagem para gado em 2008?
_____ ha

5.6.7 O que você acha do contrato com a Petrobras?
_____
_____
_____
_____

5.6.8 O que você faria caso o contrato com a Petrobras acabasse? (Você continuaria a produzir mamona?)
_____
_____

5.6.9 Você aumentaria sua área de produção de mamona caso o preço melhorasse?
sim ☐ 1
não ☐ 2

5.6.10 Você já teve alguma dificuldade ou problema com algum tipo de mamona?
sim, ☐ 1
não ☐ 2

Se **sim**:
5.11.a Com qual tipo? _____

5.11.b Qual problema?_____

[Se mais de um comprador: fazer as seguintes perguntas para cada comprador vide folhas em anexo. Sempre citar o nome de cada comprador.]

5.6.11 COMPRADOR DE MAMONA #1: _____

[SEMPRE CITAR NOME DO COMPRADOR NAS PERGUNTAS SEGUINTES]

5.6.12 Você recebe algum tipo de ajuda para a produção de mamona do comprador da mamona?
sim ☐ 1 Quem faz assistência técnica? _____
não ☐ 2 [Se não: pular para pagina 15, questão 5.6.17]

[Se **sim**:]
5.5.14.a Que ajuda? O comprador...

fornece assistência técnica?	☐ 1
fornece sementes?	☐ 2
fornece sacaria?	☐ 2a
fornece insumos?	☐ 3
ajuda na colheita?	☐ 4
faz ou cobre o transporte?	☐ 5
ajuda na armazenagem?	☐ 6
ofereceu financiamento?	☐ 7
Presta algum outro tipo de ajuda?	☐ 8 Qual? _____

[Se o comprador fornecer assistência técnica. Se não, pular para 5.6.17]:
5.6.13 Quantas vezes o técnico veio lhe visitar durante o período da última safra (2010/2011)? _____ E na safra 2011/2012? _____

[Se o comprador fornecer assistência técnica]:
5.6.14 Você está satisfeito com os serviços que tem recebido da assistência técnica?
sim, ☐ 1
não, ou ☐ 2
mais ou menos? ☐ 3

[Se **não** ou **mais ou menos**:]
5.6.16.a Por quê?_____

5.6.15 Você tem um contrato com o comprador da mamona atual?
sim ☐ 1
não ☐ 2

[Se **sim**:]
5.6.17.a Este contrato é escrito (está no papel)?
sim ☐ 1
não ☐ 2

[Se **sim**:]
5.6.17.a.a Quando você assinou este contrato? _____ (ano)

5.6.17.a.b Você está satisfeito com o contrato?
sim, ☐ 1
não, ou ☐ 2
Nem satisfeito, nem insatisfeito? ☐ 3

[Se **não** ou **nem satisfeito, nem insatisfeito**:]
5.6.17.a.b.a Se Por quê? _____
_____
_____
_____
_____

5.6.16 COMPRADOR DE MAMONA #2: _____

[SEMPRE CITAR NOME DO COMPRADOR NAS PERGUNTAS SEGUINTES]

5.6.17 Você recebe algum tipo de ajuda para a produção de mamona do comprador da mamona?
sim ☐ 1 Quem faz assistência técnica? _____
não ☐ 2 [Se não: pular para pagina 17, questão 5.6.22]

[Se **sim**:]
5.6.19.a Que ajuda? O comprador...
fornece assistência técnica? ☐ 1
fornece sementes? ☐ 2
fornece sacaria? ☐ 2a
fornece insumos? ☐ 3
ajuda na colheita? ☐ 4
faz ou cobre o transporte? ☐ 5
ajuda na armazenagem? ☐ 6
ofereceu financiamento? ☐ 7
Presta algum outro tipo de ajuda? ☐ 8 Qual? _____

[Se o comprador fornecer assistência técnica. Se não, pular para 5.6.22]:
5.6.18 Quantas vezes o técnico veio lhe visitar durante o período da última safra (2010/2011)? _____ E na safra 2011/2012? _____

[Se o comprador fornecer assistência técnica]:
5.6.19 Você está satisfeito com os serviços que tem recebido da assistência técnica?
sim, ☐ 1
não, ou ☐ 2
mais ou menos? ☐ 3

[Se **não** ou **mais ou menos**:]
5.28.d.a Por quê?_____

5.6.20 Você tem um contrato com o comprador da mamona atual?
sim ☐ 1
não ☐ 2

[Se **sim**:]
5.6.22.a Este contrato é escrito (está no papel)?
sim ☐ 1
não ☐ 2

[Se **sim**:]
5.6.22.a.a Quando você assinou este contrato? _____ (ano)

5.6.22.a.b Você está satisfeito com o contrato?
sim, ☐ 1
não, ou ☐ 2
Nem satisfeito, nem insatisfeito? ☐ 3

[Se **não** ou **nem satisfeito, nem insatisfeito**:]
5.6.22.a.b.a Se Por quê? _____
_____
_____
_____
_____

5.7 Os motivos pra decidir produzir mamona podem ser muitos. Para você, qual foi o principal, o primeiro motivo que te levou a produzir mamona?
_____
E qual foi o segundo motivo principal que te levou a produzir mamona?
_____
Existe um terceiro motivo? Qual?
_____

5.8 Em comparação com **outros agricultores familiares daqui da região que não produzem mamona**, você acha que a sua situação econômica é...
pior, ☐ 1
mais ou menos a mesma, ☐ 2
ou melhor? ☐ 3

5.9 Agora, pensando **só na sua situação**. Em comparação com o **tempo que você ainda não produzia mamona**, você acha que situação econômica sua e de sua família hoje é....
pior, ☐ 1
mais ou menos a mesma, ☐ 2
ou melhor? ☐ 3

5.10 Agora, pensando na **fartura de comida à sua mesa**. Comparando com o tempo em que você ainda não produzia mamona, você acha que hoje sua mesa **hoje** é...
menos farta ☐ 1 Por quê? _____
mais ou menos a mesma coisa ☐ 2
ou mais farta? ☐ 3 Por quê? _____

6 QUALIDADE DE VIDA

Casa e posse

[Se possível, marcar as seguintes perguntas de acordo com observação visual]:

6.1 As paredes da casa são feitas de...
Alvenaria ☐ 1
Taipa, ☐ 2
ou Madeira? ☐ 3

6.2 O telhado da casa é feito de...
telhas de barro, ☐ 1
amianto/brasilite, ☐ 2
cavacos/palha? ☐ 3

6.3 Quantos cômodos (contando sala, quarto, cozinha, etc) têm na sua casa? _____

6.4 Aqui nessa sua casa, você tem...

		QUANTO(A)S? [SE NÃO TIVER, ESCREVER "0"]
1	... energia elétrica?	Sim ☐ Não ☐
2	... água encanada?	Sim ☐ Não ☐
3	... água tratada (pela Copasa)?	Sim ☐ Não ☐
4	... Banheiro?	
5	... fogão a gás ou elétrico?	
6	... Rádio (excluindo rádio de carro)?	
7	... Televisão?	
8	... Telefone (fixo e/ou celular)?	
9	... computador?	
10	Se tiver computador: Internet?	Sim ☐ Não ☐
11	... Caminhonete?	
12	... Carro (além da caminhonete, se houver)?	
13	... Moto?	
14	... Bicicleta?	
15	... trator?	
16	... boi ou cavalo de tração?	
17	... arado?	
18	... plantadeira?	
19	... pulverizador?	
20	... enxada?	

6.5 Você está satisfeito com a sua moradia atual?
sim, ☐ 1
não, ou ☐ 2
mais ou menos? ☐ 3

6.5.1 Além desta casa aqui, você tem outra casa?
Sim ☐ 1 Onde? _____
Não ☐ 2

Vida social

6.6 Com que freqüência você vai a **reuniões** sobre questões da agricultura aqui na região?
pelo menos uma vez por semana, ☐ 1
pelo menos uma vez por mês, ☐ 2
pelo menos uma vez por semestre, ☐ 3
ou quase nunca? ☐ 4

6.7 Com que frequência você encontra com seus **vizinhos** para conversar?
pelo menos uma vez por semana, ☐ 1
pelo menos uma vez por mês, ☐ 2
pelo menos uma vez por semestre, ☐ 3
ou quase nunca? ☐ 4

6.8 Você e os outros agricultores da região se ajudam?
Sim ☐ 1
Não ☐ 2

[Se **sim**:]
9.11.a Em que atividades?
Em serviços de mão-de-obra? Sim ☐ 1 Não ☐ 2
Troca de dias? Sim ☐ 1 Não ☐ 2
Na compra de insumos? Sim ☐ 1 Não ☐ 2
Na comercialização/venda? Sim ☐ 1 Não ☐ 2
No uso de equipamentos? Sim ☐ 1 Não ☐ 2
Na compra de equipamentos? Sim ☐ 1 Não ☐ 2
Na troca de informações? Sim ☐ 1 Não ☐ 2
Em outra coisa? Qual? _____

6.9 Você é sócio ou participa de alguma cooperativa, associação ou sindicato?
Sim ☐ 1 Quais?_____
Não ☐ 2 Por que? _____

6.11.1 Você tem interesse em se **associar ou formar** alguma cooperativa ou associação?
Sim ☐ 1 Quais?_____
Não ☐ 2

[Se uma dês duas questões e sim:]

Na sua opinião, quais são as vantagens de participar neste(a)(s)

[cooperativa/associação/sindicato]?

_____
_____
_____
_____

6.10 Vou ler uma série de frases, e quero que você me diga, a cada duas frases, qual frase tem mais a ver com a sua atitude.		
Você preferiria cultivar só o produto que te dá o maior lucro. ☐ 1	ou	*Você prefere cultivar a maior variedade possível de produtos, ainda que o lucro seja menor.* ☐ 2
6.11 Vou ler outras duas frases, e quero que você me diga qual dessas frases tem mais a ver com a sua atitude.		
Para aumentar seu lucro, você não se importa em correr um risco maior. ☐ 1	ou	*Você prefere não correr riscos, ainda que seu lucro seja menor.* ☐ 2
6.12 Agora:		
Você experimenta novas técnicas e culturas, mesmo que seus vizinhos nunca tenham experimentado essas técnicas e culturas. ☐ 1	ou	*Antes que você experimente alguma técnica ou cultura nova, você espera pra ver como foi a experiência dos seus vizinhos.* ☐ 2
6.13 Outras duas frases:		
Você preferiria agregar valor a seus produtos e ganhar mais dinheiro com isso. ☐ 1	ou	*Você prefere vender seus produtos brutos para o comprador.* ☐ 2

Alimentação

6.14 Quais são **os alimentos básicos** para a alimentação de sua família?

_____
_____

6.15 Destes alimentos que você citou, você **produz algum aqui em sua propriedade** em **quantidade suficiente** para o consumo de sua família?

_____
_____

6.16 Quais dos alimentos básicos você **tem que comprar** em maior parte na feira, no mercado ou supermercado?

_____
_____

6.17 Quanto você **gasta** com suas compras do mês na feira e no (super)mercado?

_____

6.18 Comparando a quantidade de alimentos que você compra hoje no supermercado com o que você comprava 10 anos atrás, você acha que hoje você compra...
mais ☐1 Por quê? _____
menos ☐2 Por quê? _____
ou a mesma coisa
do que 10 anos atrás? ☐3

6.19 Considerando a qualidade do serviço de saúde que você e os membros da sua família receberam nos últimos dez anos, você acha que, de forma geral, esse serviço de saúde
foi bom, ☐1
ele foi ruim, ☐2
ou ele não foi nem bom nem ruim? ☐3

6.20 Pensando agora na **sua família**. Nos últimos dez anos, aconteceu **algum problema** na sua família que te afetou muito? [Se não entender, falar: Por exemplo, alguém perdeu emprego, alguma morte ou doença?]

_____
_____
_____
_____
_____
_____
_____

6.21 Qual é hoje o **maior problema** para a sua família?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

6.22 Comparando hoje com **dez anos atrás**, você acha que a situação econômica de sua família aqui na sua casa,
Melhorou ☐ 1
Continou a mesma, ☐ 2
Ou piorou? ☐ 3

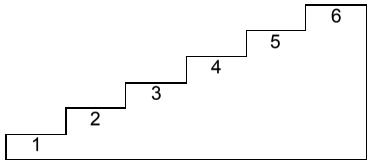
6.23 E, **daqui a dez anos**, você acha que a situação econômica de sua família aqui na sua casa vai
Melhorar ☐ 1
Continuar a mesma, ☐ 2
Ou piorar? ☐ 3

6.24 Na sua opinião, qual é o **valor mínimo** da renda suficiente para você e sua família viverem, por mês?

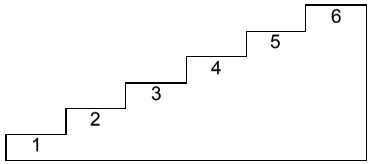
_____ R$/mês R$/ano

Imagine uma escada com seis degraus, onde no degrau mais baixo ficam os mais pobres, e no sexto degrau, o ponto mais alta da escada, ficam os mais ricos.

6.25 Em qual desses degraus, de 1 a 6, você acha que **você** está? [Mostrar escada em folha anexa]

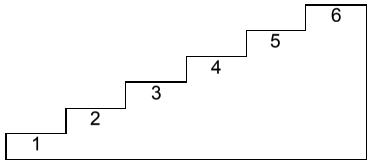


6.26 Em qual desses degraus você acha que está a maioria dos **seus vizinhos**? [Mostrar escada em folha anexa]



6.27 Agora, vamos falar sobre a sua **satisfação com a vida**. Imagine uma escada com seis degraus, onde o degrau mais baixo ficam os mais insatisfeitos [infelizes] com a vida, e no sexto degrau, o ponto mais alto da escada, ficam os mais satisfeitos [felizes] com a vida.

Em qual desses degraus, de 1 a 6, você acha que você está? [Mostrar escada em folha anexa]



7 FINANÇAS E CRÉDITO

7.1 Você já pegou dinheiro emprestado ou já fez algum financiamento?
Sim ☐ 1
Não ☐ 2

[Se **sim**:]
7.1.a De quem ou da onde?

Banco	☐ 1
Pronaf	☐ 2
Outro Programa do Governo	☐ 3
Cooperativa, associação ou sindicato	☐ 4
Vizinho ou amigo	☐ 5
Parente	☐ 6
Outro. Qual?_____	☐ 7

7.1.b Qual foi o valor desse(s) crédito(s)? R$ _____

7.1.c Quanto você ainda tem que pagar? R$ _____

7.1.d Em que você usou esse crédito? (Para quais atividades da agricultura ou pecuária?)
_____
_____
_____

[Se **não**:]
7.1.e Por quê? Você...

Nunca precisou,	☐ 1
Não foi aprovado pela instituição (sua ficha),	☐ 2
Não soube como conseguir,	☐ 3
Tem medo de endividar,	☐ 4
Nunca pegou dinheiro emprestado antes,	☐ 5
Por causa da burocracia,	☐ 6
Ou por não ter garantia pessoal?	☐ 7
Outro. Qual?_____	☐ 8

7.2 Você gostaria de pegar algum crédito ou financiamento?
Sim ☐ 1 Para que? _____
Não ☐ 2

8 RENDA E OUTRAS RECEITAS

8.1 Qual foi o seu lucro (receita menos gastos), no ano de 2011 (ano passado), pelas atividades agropecuárias aqui em seu estabelecimento?
R$ _____

8.2 Em que especificamente você gastou a renda que você teve?
_____
_____
_____

[Se **não teve lucro**:]
8.3 Você teve prejuízo? De quanto? R$ _____

8.4 Você ou alguém da sua família que mora aqui exerce **alguma outra atividade aqui no seu estabelecimento**, além das atividades agropecuárias? (por exemplo, aluguel de máquinas ou animais, pesca, extrativismo, madeira, carvão?)
Sim ☐ 1
Não ☐ 2
[Se **sim**:]

Quem?	Qual(is) atividade(s)?	Quanto recebe?	por mês ou ano?

8.5 Você ou alguém de sua família que mora aqui exerce **algum trabalho fora do seu estabelecimento** ou tem **algum outro emprego**?
Sim ☐ 1
Não ☐ 2
[Se **sim**:]

Quem?	Qual(is) trabalho(s)?	Quanto recebe?	por mês ou ano?

[*Quando o entrevistado não souber quanto ele ganha por mês ou ano, perguntar quanto ele ganha por dia e quantos dias por ano ele trabalha e então calcular.]

8.6 Você ou algum familiar que mora aqui com você recebe **aposentadoria ou pensão**?
Sim ☐ 1
Não ☐ 2
[Se **sim**:]

Quem? (parentesco do membro)	Quanto recebe (por mês)?

8.7 Você e sua família recebem algo do **Bolsa Família**?
Sim ☐ 1 Quanto (por mês)? _____ R$/mês
Não ☐ 2

8.8 Você ou algum membro da sua família que mora aqui com você **recebe algo de algum outro programa do governo**?
Sim ☐ 1
Não ☐ 2
[Se **sim**:]

Qual programa?	Quanto recebe (por mês)?

8.9 Você recebe **ajuda financeira de algum parente ou amigo**?
Sim ☐ 1 Quanto? _____ R$/mês R$/ano
[se não souber: perguntar quanto foi no ano passado – 2011].
Não ☐ 2

8.10 Além dessas que falamos, você tem alguma **outra fonte de renda**?
Sim ☐ 1
Não ☐ 2
[Se **sim**:]

Qual?	Quanto recebe (por mês)?

8.11 Vou ler agora duas frases e gostaria que você me dissesse qual das duas tem mais a ver com você. Com a sua renda atual...

Com a sua renda atual você consegue guardar algum dinheiro ☐ 1
ou
Com a sua renda atual você gasta tudo o que você recebe? ☐ 2

[Se escolheu opção 1:]
Quanto dinheiro você conseguiu juntar/economizar no ano passado (2011)? ____

8.11.1 COMPRADOR DE MAMONA #3: _____

[SEMPRE CITAR NOME DO COMPRADOR NAS PERGUNTAS SEGUINTES]

8.11.2 Você recebe algum tipo de ajuda para a produção de mamona do comprador da mamona?
sim ☐ 1 Quem faz assistência técnica? _____
não ☐ 2 [Se não: pular para pagina 30, questão 8.11.5]

[Se **sim**:]
8.11.2.a Que ajuda? O comprador...
fornece assistência técnica? ☐ 1
fornece sementes? ☐ 2
fornece sacaria? ☐ 2a
fornece insumos? ☐ 3
ajuda na colheita? ☐ 4
faz ou cobre o transporte? ☐ 5
ajuda na armazenagem? ☐ 6
ofereceu financiamento? ☐ 7
Presta algum outro tipo de ajuda? ☐ 8 Qual? _____

[Se o comprador fornecer assistência técnica. Se não, pular para 8.11.5]:
8.11.3 Quantas vezes o técnico veio lhe visitar durante o período da última safra (2010/2011)? _____ E na safra 2011/2012? _____

[Se o comprador fornecer assistência técnica]:
8.11.4 Você está satisfeito com os serviços que tem recebido da assistência técnica?
sim, ☐ 1
não, ou ☐ 2
mais ou menos? ☐ 3

[Se **não** ou **mais ou menos**:]
8.11.4.a Por quê?_____

8.11.5 Você tem um contrato com o comprador da mamona atual?
sim ☐ 1
não ☐ 2

[Se **sim**:]
8.11.5.a Este contrato é escrito (está no papel)?
sim ☐ 1
não ☐ 2

[Se **sim**:]
8.11.5.a.a Quando você assinou este contrato? _____ (ano)

8.11.5.a.b Você está satisfeito com o contrato?
sim, ☐ 1
não, ou ☐ 2
Nem satisfeito, nem insatisfeito? ☐ 3

[Se **não** ou **nem satisfeito, nem insatisfeito**:]
8.11.5.a.b.a Se Por quê? _____
_____
_____
_____
_____

8.11.6 COMPRADOR DE MAMONA #4: _____

[SEMPRE CITAR NOME DO COMPRADOR NAS PERGUNTAS SEGUINTES]

8.11.7 Você recebe algum tipo de ajuda para a produção de mamona do comprador da mamona?
sim ☐ 1 Quem faz assistência técnica? _____
não ☐ 2 [Se não: pular para pagina 31, questão 8.11.10]

[Se **sim**:]
8.11.7.a Que ajuda? O comprador...
fornece assistência técnica? ☐ 1
fornece sementes? ☐ 2
fornece sacaria? ☐ 2a
fornece insumos? ☐ 3
ajuda na colheita? ☐ 4
faz ou cobre o transporte? ☐ 5
ajuda na armazenagem? ☐ 6
ofereceu financiamento? ☐ 7
Presta algum outro tipo de ajuda? ☐ 8 Qual? _____

[Se o comprador fornecer assistência técnica. Se não, pular para 8.11.10]:
8.11.8 Quantas vezes o técnico veio lhe visitar durante o período da última safra (2010/2011)? _____ E na safra 2011/2012? _____

[Se o comprador fornecer assistência técnica]:
8.11.9 Você está satisfeito com os serviços que tem recebido da assistência técnica?
sim, ☐ 1
não, ou ☐ 2
mais ou menos? ☐ 3

[Se **não** ou **mais ou menos**:]
8.11.9.a Por quê?_____

8.11.10 Você tem um contrato com o comprador da mamona atual?
sim ☐ 1
não ☐ 2

[Se **sim**:]
8.11.10.a Este contrato é escrito (está no papel)?
sim ☐ 1
não ☐ 2

[Se **sim**:]
8.11.10.a.a Quando você assinou este contrato? _____ (ano)

8.11.10.a.b Você está satisfeito com o contrato?
sim, ☐ 1
não, ou ☐ 2
Nem satisfeito, nem insatisfeito? ☐ 3

[Se **não** ou **nem satisfeito, nem insatisfeito**:]
8.11.10.a.b.a Se Por quê? _____
_____
_____
_____
_____

Annex 2: Point system for the calculation of economic class

Variables	Number of items				
	0	1	2	3	4 or +
Electric energy	0	3	3	3	3
Tap water	0	3	3	3	3
Treated water (by Copasa)	0	3	3	3	3
Bathroom	0	4	5	6	7
Wood stove	0	1	1	1	1
Gas or electric stove	0	3	3	3	3
Radio (excluded car radio)	0	1	2	3	4
Colour television	0	1	2	3	4
Telephone (landline and/or mobile)	0	3	3	3	3
Computer	0	4	4	4	4
Internet	0	2	2	2	2
Pick-up truck	0	4	7	9	9
Car	0	4	7	9	9
Motorcycle	0	3	4	4	4
Bicycle	0	2	3	3	3
Motor-lorry	0	6	9	11	11
Tractor	0	5	8	10	10
Workhorse or ox	0	2	3	3	3
Harvester	0	3	4	4	4
Plough	0	3	4	4	4
Planter	0	2	3	3	3
Spreader	0	2	3	3	3
Hoe	0	1	2	2	2
Disintegrator	0	2	3	3	3
Harrow	0	2	3	3	3
Scythe	0	2	3	3	3
Grubber	0	2	3	3	3

Annex 3: Threshold criteria for economic classes

Socioeconomic class	Points
A1	70 - 79
A2	60 - 69
B1	50 - 59
B2	40 - 49
C1	30 - 39
C2	20 - 29
D	10 - 19
E	0 - 9